STUDENTS' SYNOPSIS SERIES

·HYGIENE·

JAMESON & MARCHANT

J. & A. CHURCHILL.

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HYGIENE

STUDENTS' SYNOPSIS SERIES

HYGIENE

SPECIALLY INTENDED FOR THOSE STUDYING
FOR A DIPLOMA IN PUBLIC HEALTH

BY

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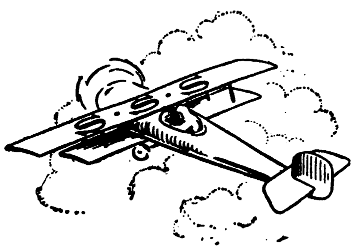
WITH 18 ILLUSTRATIONS



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PREFACE

This little book is an attempt to epitomise the views of accepted authorities and the most recent work in the huge subject of Hygiene. It is really a carefully edited collection of the notes used by the authors for teaching purposes at University College. Those sections dealing with purely practical subjects have been cut down to make room for more theoretical material, and it is hoped in consequence that the manual will prove useful for rapid revision of D.P.H. examination work. A good many references to literature will be found in the text, and a list of standard books is inserted on p. 389. Grateful acknowledgment is now made for the assistance given us by these works, not only in the somewhat strenuous task of preparing candidates for the various Public Health Diplomas, but also in the writing of this Synopsis. We are indebted to the publishers for permission to reprint various diagrams from Notter and Firth's *Theory and Practice of Hygiene*, and Hamer's *Manual of Hygiene*.

W. W. J.
F. T. M.

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A SYNOPSIS OF HYGIENE

SECTION I

WATER SUPPLIES

One portion of the water deposited on the earth flows away on the surface, another portion percolates downwards, and a third part, amounting on an average to 25%, is evaporated.

GEOLOGY OF WATER SUPPLIES

The crust of the earth, as known to man, is divided into periods, in accordance with the nature or development of the fauna which are present in the various strata.

The following may be regarded as a broad classification—

Quaternary	Recent or Post-glacial.	The human or present period.
	Pleistocene or Glacial.	Boulder clay.
Neozoic or Cainozoic Period or Tertiary. The Period of Recent Life.	Pliocene.	Norfolk crag.
	Milocene.	Sand and gravel rock. Here we see the approach to the fauna of the present day.
	Oligocene.	Sand, clay and limestones, found most particularly in the Isle of Wight.
	Eocene.	Sand, clay. Bagshot sand. London is on this period.
Mesozoic or Secondary Period.	Cretaceous.	Chalk and greensand.
	Jurassic.	Oolite, limestones, Portland and Oxford stones.
	Triassic	New red sandstone.
Palæozoic or Primary Period. The Period of Ancient Life.	Permian.	Mag. limestone, sandstones.
	Carboniferous.	Coal measures.
	Devonian.	Old red sandstone.
	Silurian.	Slates, sandstones.
	Cambrian.	Welsh sandstone, etc.
Archean or pre-Cambrian.		Gneiss and schists.

The chief water-bearing formations are: Pleistocene, Pliocene, Oligocene, Eocene, Cretacious, Jurassic, Triassic, Permian, Carboniferous, and Devonian. Their capacity for yielding good supplies is exceedingly variable. It would be indiscreet to trust

to generalisations, both as to quality and quantity. It is necessary to give particular attention to each formation, and to the local conditions where the water supply is required. It is obvious that a permeable stratum is porous, but the converse is not necessarily true, as certain strata have definite powers of imbibition, but, when saturated, they become practically impermeable. The porous and permeable hold water throughout their mass, and would yield a supply if tapped. The others may be considered impervious in mass, but contain water in joints, fissures, and other cavities, and consequently become water-bearing only if a joint, fissure, or cavity is tapped.

A fissure is a cavern produced by erosion, or by the action of water containing free carbonic acid on such a stratum as chalk. A bicarbonate of calcium is formed, which is soluble, and so in the course of time a fissure is produced. If this action takes place in a superficial stratum, from the surface downwards, "swallow holes" are formed, through which water is diverted underground. These constitute a danger, as gross pollution, unacted upon by the natural purifying agencies of the soil, may gain access to a drinking-water supply.

All geological formations, whether porous or not, are disposed with horizontal stratification, or with a "dip" or inclination in a certain direction. They may be bent into folds or saddles, known as "anticlines," or in the form of basins, known as "synclines." By denudation and other processes, the surface may get changed, so that a valley may be over an "anticline," or a hill above a "syncline." The surface, therefore, is no indication of the underground formation. The topography is of little value in determining water supplies, it is the strata below which are the factors concerned when prospecting for water. By contraction and pressure, formations are liable to fracture with consequent displacement, either upwards or downwards. This dislocation or breach of continuity is called a "fault." The "throw," that is the amount which represents the vertical displacement, may give rise to an "overthrust," whereby an older formation is thrust over a newer, or where a stratum loses its continuity and becomes contiguous with a different stratum altogether. It is easy to imagine a fault causing a spring, or to explain why one well yields a prolific supply, and yet another only a few feet away little or none. The angle between the fault or plane of fracture and the vertical is known as the "hade." With the aid of a geological map one can often predict that, within certain limits, a water supply is obtainable at a certain spot at a certain depth. Let us suppose that sand, clay, and limestone come to the surface, that is, they "outcrop." It is obvious that they must dip or incline in one direction or the other. On consulting the "Key" of the strata on the side of the map, one can learn which is the oldest formation, as the

strata are invariably arranged in order of age. If, for example, the limestone is the oldest, it must run under the sand. In that way the direction of the dip is known. The following diagrams will make it clear—

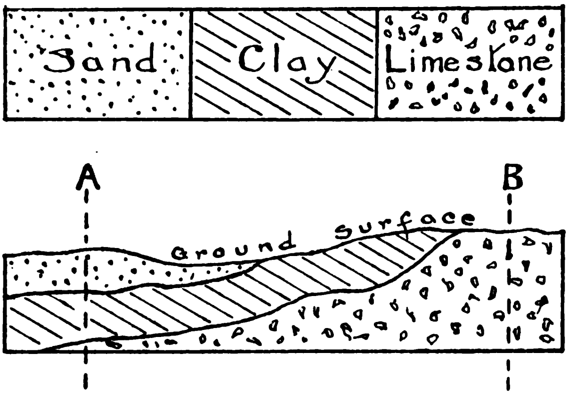

FIG. 1.

A well sunk at B would tap the water in the limestone. A well sunk at A would first tap the water in the sand resting upon the impermeable stratum of clay, but, if sunk perhaps only a few feet lower, it would also tap the water in the limestone.

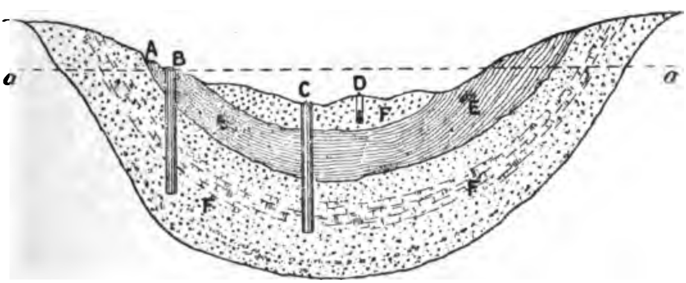

FIG. 2.—A . . . *a*, plane of saturation or level of underground water in deeper pervious stratum, FF. B is a deep or sub-artesian well and C an artesian well, bored through the impervious stratum EE into the pervious stratum FF. D is a shallow well.

The level at which the water stands in the earth is known as the "plane of saturation" or "water table." It assumes the same curve as the surface of the earth above it, but to a less degree. It is the water table that determines artesian and subartesian wells.

The characters of a water depend entirely upon the strata

through which it has percolated. As regards organic contamination, deep-seated water is the purest, but even the clearest water may be dangerously polluted; more particularly is this the case with shallow well water and some springs. All waters contain in solution a certain proportion of gases and mineral matter. The amount of inorganic solids dissolved, as a rule, increases with the depth. Waters from the chalk, Silurian limestones, carboniferous and magnesium limestones, calcareous sandstones, oolite, and greensand are usually very hard on account of the calcium carbonate and calcium sulphate which enter into their composition. Greensand water is typified by its high saline ammonia content, the absence of, or very small amount of, oxidised nitrogen, and the comparative excess of chlorides. Soft waters are obtained from most upland surfaces, also from the Cambrian, Silurian, and Devonian slates, and from some of the sandstones and new red sandstone, if they are near the surface or find an outcrop. Water flowing over granite and gneiss is almost invariably pure and soft.

SOURCES OF SUPPLY

1. **Rainwater.**—One inch = 4·673 gallons per sq. yard = 101 tons per acre. Average rainfall in England = about 34 inches. (Twenty-five inches in East Anglia, more in the west.)

The average rainfall for twenty years $-\frac{1}{3}$ = approximately the fall in the driest year.

The average rainfall for twenty years $+\frac{1}{3}$ = approximately the fall in the wettest year.

Rainwater is very pure under country conditions, but in towns it is apt to be contaminated with acids, etc., in the atmosphere. It contains certain dissolved gases, very little solid matter, and is liable to have a solvent action on metals. It is collected usually from roofs or specially prepared impermeable surfaces. In estimating the roof-collecting area, neglect the slope of the roof and reckon only the horizontal receiving surface. The steeper the pitch of the roof, the less will be the loss from evaporation. The first portion falling must be discarded, as it contains any filth deposited on the roof. Roberts' "rainwater separator" allows a certain amount of water to run to waste. Meanwhile, a "tipper" is slowly filled, which, when full, cants, owing to an alteration of its centre of gravity, diverting the water now to the storage tank. The water should be stored in a properly built and protected cistern, preferably underground, never made of lead. Such water is excellent for washing purposes, on account of its softness, but its insipid taste renders it unpleasant to drink.[1]

2. **Upland Surface Water.**—Such supplies are derived either from natural lakes in moorland districts, or from "impounding

[1] Houston has advocated the treatment of domestic rainwater supplies by the excess-lime method (p. 14).

reservoirs" constructed to collect water flowing off the adjoining hills. About 120 days' supply should thus be stored in this country. The area draining into the reservoir is known as the "catchment area." A catchment area may be accurately marked out on a 6-inch ordnance survey map. This shows—

(1) "Contour lines," or lines drawn through points of equal altitude at every rise of 100 feet up to 1000 feet, and then at intervals of from 100 to 250 feet. In some of the lower levels 25-feet contour lines are shown.

(2) "Ridge lines," or lines drawn along the tops of watersheds.

(3) "Bench mark" figures indicating altitude to one decimal place, *e. g.* ⩚ B.M. 100·5 means that the Bench Mark ⩚ cut on some stone is 100·5 feet above ordnance datum. Ordnance datum is the mean sea-level at Liverpool, which is 0·65 foot below the mean level of the sea round the coast.

The selected area should be well fenced in, any buildings and farms within it should be under the rigid control of the water authority, and no individuals should be allowed to wander at large over it. All water channels should be partially built up where necessary, and kept clean. Any unsuitable feeders should be cut out, and provision should be made to prevent the entrance of turbid flood water into the reservoir. Such waters, if sufficiently protected, form satisfactory supplies. They are, however, often discoloured with peaty matter, and not infrequently have a solvent action on lead. They are usually very soft.

3. **Rivers.**—The character of the water varies according to the country through which it flows and the tributaries that enter it. Most rivers of any size in this country are grossly contaminated, and it is said that none of our rivers is long enough to purify itself completely by natural means. Natural means are: (1) Dilution, (2) Oxidation by bacterial action, (3) Sedimentation, (4) Action of fish and small water animals, (5) Sunlight—only in the upper few feet. Weirs are sometimes placed in the course of a river to assist self-purification. Control must be exercised over all waters discharged into a river above the intake of a water supply, *e. g.* sewage works' effluents and trade wastes. That pure water can be obtained from polluted rivers, under proper precautions and after suitable treatment, is instanced by the London supply.

The yield of a stream may be calculated (*a*) by estimating the cross-sectional area and multiplying this by four-fifths of the surface velocity per minute—the result will be cubic feet per minute, (*b*) by meter, or (*c*) by special formulæ.

Only a certain amount of water may be abstracted—a fixed amount known as "compensation water" must be allowed to pass on for the benefit of mill-owners, etc., lower down.

Water is sometimes got from rivers by digging trenches parallel with the bank and at some little distance from the river. By

these means water, more or less purified by filtration through the intervening soil, may be obtained. Frequently, however, only the subsoil water percolating towards the river is tapped.

4. **Underground Water.**—Water lying above the first impermeable layer is known as subsoil or ground water. This water rises and falls according to the season of the year and the rainfall. It is highest in February and March, and lowest in October and November, the rise being due to lessened evaporation and greater percolation. In addition, this water is always moving slowly towards its natural outlet either in springs, rivers, or the sea, the actual direction depending on the dip of the strata. Such water, of course, collects any impurities that may enter it from the surface.

Natural means of purification in soil.—By bacterial action in the upper few inches of the soil complex organic material is broken down into its simpler elements, C, N, and H—these are evolved as CO_2, H_2O, NH_3, NO and NO_2. The oxidation of the N is due to nitrifying organisms whose work is divided into two clear categories, (*a*) "nitritification," and (*b*) "nitratification." In the former, oxidation of N to NO is performed, and in the latter, oxidation of NO to NO_2. As a result of this action, nitrous and nitric acids are formed, and unless these acids have bases to combine with to form nitrites and nitrates the nitrifying organisms will be killed by their own acid products. Nitrates represent the completely oxidised state of the N. The requirements of these nitrifying organisms are: (1) Oxygen, (2) moisture, (3) suitable temperature (optimum about 37° C.), and (4) bases such as Ca. It will be seen later, in the land purification of sewage, that a "sewage-sick" land is nothing more than soil where all the bases have been used up, with the resulting death of the nitrifying organisms in the acid medium.

Ground water lying near the surface is thus liable to be grossly contaminated by animal organic matter that has not undergone sufficient natural purification.

Shallow wells tap the subsoil water. On prolonged pumping in such a well a "cone of depression" is said to be formed—an inverted cone with the well as its apex. The result may be a sucking in of water from as great a distance as 100 to 160 times the depression of the water in the well produced by the pumping. The exact distance drained, known as the "drainage area," depends on the porosity of the soil.

Requirements of a good well.—(1) Situated at least 100 feet away from any cesspool, manure-heap, etc. The flow of the ground water should be from the well towards these, never in the opposite direction. (2) The site should be slightly elevated to avoid the entrance of flood water. (3) A space of 100 feet all round should be railed off. (4) Water-tight lining—bricks set in cement or cast-iron cylinders to a depth of 20 feet. (This depth will usually ensure a fair amount of filtration of surface

water before it enters the well.) (5) The lining should be carried up as a coping 2 to 3 feet above ground, and there should be a cemented area extending 6 feet out from the well-mouth all round, and sloping so as to carry off all spilt water to some suitable drain. (6) Proper cover and pump.

Tube wells consist of lengths of iron tubing, with screw-in unions, driven into the ground to the requisite depth. The first length is pointed, and has perforations to allow of the entry of water. Water is raised by a pump attached to the top section. These form a rapid means of obtaining ground water, but in sandy soils they are apt to become clogged.

The yield of a well may be reckoned by noting the sectional area of the bore, and observing how long the water takes to reach a fixed point in the well after being lowered by pumping to a known depth.

Subsoil or surface springs are natural outcroppings of ground water due to the approach of the first impermeable stratum to the surface. They are either constant or intermittent, depending on the rise and fall of the ground water. The same precautions must be taken as in shallow wells, with regard to site, etc. The spring should be covered in and the water led to the surface by a pipe. The yield of a spring may be estimated by finding how long it takes to fill a vessel of known capacity.

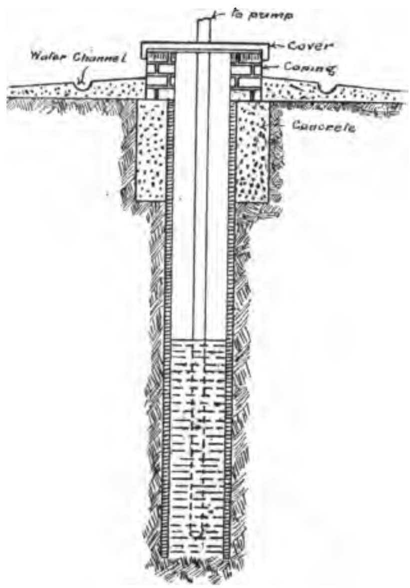

FIG. 3.—Well, suitably protected.

Deep wells tap some water-bearing layer below the first impermeable stratum. They usually yield more permanent supplies than do shallow wells, and the water is often of great purity, but apt to be hard and contain a good deal of dissolved salts, depending on the stratum from which the water is drawn.

Such wells must be protected in the same way as shallow wells, and the water-tight lining should be carried down to the first impermeable layer, and a water-tight joint made there. Many have horizontal galleries driven into the strata through which they pass, to tap additional water-bearing areas. A

mechanically driven pump usually has to be employed to raise the water. In such wells surface pollution may enter through a fissure, *e.g.* in chalk. Near the coast the water may show a tendency to become brackish. If a source of contamination is suspected in the neighbourhood of a well, the following method of examination may be adopted—

To the area, which is supposed to be polluting the well, add one of the following—

(*a*) Alkaline solution of fluorescein: *e.g.* 1 lb. fluorescein and 1 lb. caustic soda in 10 gallons of water—1 part of fluorescein causes fluorescence in 10,000,000 parts of water.

(*b*) Strong solution of lithium sulphate—spectrum of lithium may be seen subsequently in the water.

(*c*) Strong solution of ordinary salt—may produce increase of chlorides in the well water.

(*d*) Suspension of B. prodigiosus—red colonies may later be grown from the water.

In all cases the well should be pumped thoroughly for some days before and after any of the above procedures is adopted, and the water entering the well examined for some days on end.

Artesian wells tap a water-bearing stratum whose outcrop is on a higher level than the mouth of the well. The water issues from the boring without any pumping. *Sub-artesian wells* are modifications of the foregoing in that the water rises only part of the way up the boring, the water-table in this case lying at a somewhat lower level than the well-mouth.

Deep springs deliver water from a deep water-bearing stratum, usually through a fault in the rocks. They may be polluted in the same way as deep wells. Some such springs are heavily charged with gases or saline matter, and constitute the so-called medicinal springs.

5. **Distilled Water** is much used on board ships. It requires to be aerated before use, and block-tin lined pipes should be used in the apparatus, as distilled water has a solvent action on lead and copper.

Amount of water required per head per day in a community (after Parkes and Kenwood).

		Gallons.
Household.	Drinking	0·33
	Cooking	0·75
	Personal washing	5·00
	Dish and house washing	3·00
	Laundry	3·00
	W.C.	5·00
Trade purposes		5·00
Municipal.	Street cleaning. Public baths, etc. Flushing sewers. Fire extinguishing.	5·00
Unavoidable waste		3·00
		30·08

A complete bath requires 30–40 gallons.

Horse allowance, about 16 gallons. Cow allowance, 10 gallons.

In hospitals about 40–50 gallons per head are allowed.

Any water supplied must be chemically and bacteriologically pure and should not have a solvent action on metals.

Water may be unsatisfactory for any or all of the following reasons—

1. At the source.	Excessive hardness. Animal contamination. Vegetable ,,
2. In transit.	Entrance of sewage or gas into the mains. Solution of metals such as lead.
3. In consumers' premises.	Entrance of filth of all sorts on account of faulty storage. Solution of metals.

PURIFICATION OF WATER ON A LARGE SCALE

A. **Removal of Hardness.**—Temporary hardness is due mainly to the carbonates of Ca and Mg and permanent hardness to the sulphates. Hardness is objectionable in that—

1. It is wasteful of soap (1 lb. of chalk consumes 9 lbs. of soap).
2. It is harmful to the skin.
3. It lessens the digestibility of food cooked in it.
4. It deposits in pipes and boilers, forming a scale which may occlude the former or cause wastage of fuel in heating the latter.

It is the temporary hardness that deposits most readily, but, at high temperatures and under pressure, sulphates crystallise out forming a very hard and obstinate deposit. Boiler explosions may be caused by the sudden cracking of the scale and the subsequent contact of the water with the overheated metal of the boiler.

Temporary hardness may be removed, (*a*) by boiling (impracticable on a large scale), or (*b*) by addition of lime, as follows—

$$CaCO_3 . CO_2 + Ca(OH)_2 = 2CaCO_3 + H_2O.$$

The lime, of course, combines with any free CO_2 in the water, so that practically more is required than is theoretically demanded. A useful working rule is—add 1 oz. of CaO per 700 gallons for every grain of temporary hardness (degrees Clark) to be removed per gallon.

Clark's Process consists of—(1) Addition of the necessary amount of CaO, usually as 10% milk of lime—done frequently by a mechanical regulator. (2) Thorough mixing. (3) Sedimentation. (4) Drawing off the clarified and softened upper layer. Sedimentation is very slow, the precipitate of $CaCO_3$ settling at anything from 2½–12 inches an hour: hence some sort of filtration through linen or fibre screens, or quartz, is usually

adopted. Sedimentation alone would require a period of about twelve hours.

Permanent hardness may be removed by the addition of soda or caustic soda, with the formation of a harmless sulphate of soda.

$$CaSO_4 + Na_2CO_3 = Na_2SO_4 + CaCO_3.$$

In the case of a water containing considerable permanent as well as temporary hardness a mixture of both CaO and Na_2CO_3 is sometimes employed.

Permutit.—This is the trade name for a combination of silicate of alumina and soda. When a hard water is filtered through this medium, the Ca and Mg take the place of the Na, which passes off in the outflow. Thus—

$$Na_2Al_2Si_2O_8 + CaSO_4 = CaAl_2Si_2O_8 + Na_2SO_4.$$

As the efficiency of the Permutit gradually lessens, it is necessary to restore it by treating the medium for some hours with a strong solution of common salt. By "mass action" the Na displaces the Ca and Mg. Thus—

$$CaAl_2Si_2O_8 + 2NaCl = Na_2Al_2Si_2O_8 + CaCl_2,$$

and the life of the filter is completely renewed.

B. **Removal of Organic Pollution.**—

Methods—

1. Storage.
2. Filtration. . $\begin{cases}\text{Sand filtration.}\\ \text{Mechanical filtration.}\end{cases}$
3. Sterilisation. $\begin{cases}\text{Chlorination.}\\ \text{Addition of excess lime.}\\ \text{Ozonisation.}\\ \text{Ultra-violet rays.}\end{cases}$

1. **Storage** should be considered a preliminary to some form of filtration. The results of storage are, according to Houston—

(*a*) In raw river water, artificially infected with large numbers of B. typhosus, 99·9% of the organisms are killed by one week's storage under laboratory conditions. Under similar circumstances the vibrio of cholera cannot be detected in 100 c.c. of water after three weeks. (*b*) Stored under natural conditions, river water shows a reduction of 90% in the number of B. coli after three weeks' storage, and most of those that remain are atypical. (*c*) Some improvement is effected in the chemical composition of the water. (*d*) Sedimentation of suspended matters takes place with subsequent longer life of filter beds. (*e*) Four weeks' storage renders a water "safe" prior to filtration, it lessens risk from faulty action of the filters, and prevents the necessity of drawing water from rivers when in flood.

Growth of algæ in storage reservoirs may take place, especially in late spring. Unpleasant taste and smell may result, *e.g.* from anabæna. Small algous growths tend to be washed down

on to filter beds and cause clogging. The best treatment for such growths is the addition of 2–10 lbs. of copper sulphate per 1,000,000 gallons of water. This may be applied by towing a bag of the salt through the reservoir behind a boat. It is better to use copper sulphate as a preventive, otherwise the dead, decomposing vegetable matter may make the water unfit to use for some time. Bleaching powder, in the proportion of 1 part of available chlorine per 1,000,000, is also effective. Objectionable taste due to algal growths can, in certain cases, be removed by the addition of about 5 lbs. of potassium permanganate per million gallons of water. Small reservoirs may be covered over to discourage such growths.

2. **Filtration.**—*Open sand filters* usually deal with stored water. They are on an average 5 feet thick. There is a top layer of 2½–3 feet of fine sand resting on a lower stratum of coarse gravel. A depth of 18 inches of water is usually maintained on the top, although in some cases a much greater depth is customary. The speed of filtration is about 2½ million gallons per acre per day, representing a rate of some 4 inches per hour through the filtering medium. Pipes are placed vertically in the sand to allow of escape of air when the beds are being filled, and the filtered water is collected in channels on the floor and led to a filtered water well. The upper layer of sand gets coated with a slimy deposit of algal growths, bacteria, and organic matter of all sorts. The efficiency of the filter depends mainly on the mechanical action of this layer. The denser the film, the slower will be the rate of filtration, and a greater head of water will be required to ensure delivery of the necessary amount of water. At intervals (usually of six to eight weeks) the top few inches of sand will have to be removed. When the fine sand layer is thus reduced to 12 inches, it is necessary to re-sand the bed—usually about every three years. The new film takes about three days to form, during which time the water must be allowed to pass very slowly through the bed. In some instances the first water is allowed to run to waste. Should the filter crack, or the surface layer of sand get disturbed in any way, unfiltered water may pass direct to the mains. Good management aims at avoiding such accidents. Rigid control must be maintained by frequent bacteriological examinations of the filtered water.

Preliminary storage followed by sand filtration is the purification process as practised by the Metropolitan Water Board. The constant excellence of the London water supply is sufficient praise of the method.

Coagulants, such as sulphate of alum, may be added to water where a long period of storage is impracticable. Alumino-ferric, containing about 50% of sulphate of alum and 1% sulphate of iron, is also used. There should be subsequent sedimentation

for several hours. Amounts varying from 1–6 grains of the coagulant per gallon may be required.

Value of coagulants—(1) They hasten the deposition of suspended matter. (2) They produce an artificial surface film in much less time than the natural one takes to form. (3) They allow of much more rapid filtration.

Coagulants are added usually to water that is to pass through what is known as a mechanical filter, shortly to be described.

Anderson Process.—Water travels through a cylinder revolving on its long axis, and comes into intimate contact with scrap-iron which is thrown through the water by baffle plates on the sides of the cylinder. A small amount of oxide of iron is thus carried away in the water. On aeration this oxide separates out, carrying suspended matter down with it. The clarified water is finally filtered through sand beds.

Mechanical Filters.—A coagulant is usually added to the water in the first instance, with or without a subsequent period of sedimentation. In English filters the practice is to add the coagulant directly to the water as it enters the filter. The filtering medium, sand or quartz, is contained in a tall metal cylinder which may or may not be closed at the top. If open, it is a gravity filter, if closed, a filter under pressure. The water containing the coagulant is passed to the top of the cylinder, and flows downwards through the medium to an outlet at the bottom. An artificial film is formed in from fifteen to twenty minutes, during which time the water is allowed to run to waste. On account of the rate of filtration, 200 inches an hour or more, the medium tends to clog with the arrested organic matter, and has to be cleaned frequently—once or twice a day as a rule. Cleansing is accomplished by shutting off the entering water and passing a reverse current of filtered water from a reservoir through the medium, at the same time agitating the sand by means of revolving metal arms or a blast of compressed air. This process lasts only a few minutes and consumes about 1–4% of the filtered water. Some filters are provided with a pre-filter to remove the coarser matters in suspension.

In the Candy mechanical filter, a medium called "polarite" is used. It is composed mainly of magnetic oxide of iron, and, being very porous, contains a good deal of oxygen in its substance. It is particularly useful in removing iron from water. The oxygen is renewed during cleansing, which is done by a reverse current of clean water without the aid of revolving arms or compressed air. In the Candy Dechlor filter the water is first chlorinated (any excess of chlorine being subsequently removed) and then filtered, the whole process being carried out in the one cylinder.

Mechanical filters are cheaper to instal than sand filter beds, they occupy much less space, they can be housed anywhere, and

they give a very rapid delivery of water. Under skilled supervision, as good results are got as in the case of sand filtration.

3. **Sterilisation of Water** aims at the destruction of all organisms of intestinal origin. It would be impracticable to attempt to kill water organisms or spores.

(*a*) **Chlorination.**—Bleaching powder method.

$$\underbrace{\text{In water } 2CaOCl_2}_{\text{Calcium oxychloride or the active agent in the powder}} = \underbrace{Ca(OCl)_2}_{\text{(Hypochlorite)}} + CaCl_2$$

$$Ca(OCl)_2 + H_2CO_3 = CaCO_3 + 2HClO.$$

$$2HClO = 2HCl + O_2.$$

The process is therefore really an oxidising one. The term "available chlorine" is only a measure of the available oxygen, but the amount of bleaching powder to be added to a water is always expressed as so many parts of "available chlorine" per 1,000,000. Good bleaching powder should contain from 30–33% "available chlorine," but it deteriorates rapidly on exposure to the air. It is advisable to remove gross organic matter from a water prior to chlorination, otherwise no oxygen will be left to destroy the bacterial impurities. That being done, any ordinary water should be rendered reasonably safe for drinking purposes by half an hour's contact with 1 part of "available chlorine" per 1,000,000. In cold weather the action is less rapid. This means the addition of some 30 lbs. of good bleaching powder per million gallons of water. The exact amount, however, must be estimated by experiment, particularly bacteriological. The necessary amount of bleaching powder should be mixed with water in a cement or wooden tank. Galvanised iron should be used only if coated with a bituminous paint, as the solution will rapidly erode the metal. The mixture should then be allowed to settle and finally added to the water in the required proportions. The strength of this solution should be estimated daily in order to avoid error. Sufficient period of contact may be given in long aqueducts or in small reservoirs. Added prior to filtration, it appears to have no injurious effect on the film formed on the surface of sand filters. The method is cheap and may possibly take the place of storage on a large scale. It is an excellent method for sterilising a water supply when an outbreak of *e. g.* typhoid is suspected to be water-borne. The objection to the process is that any excess of bleaching powder left over is apt to produce an unpleasant taste. This can be avoided by careful dosage; and various means, *e. g.* filtration through animal charcoal, have been adopted to obviate any such risk (*vide* Candy Dechlor filter).

Swimming Baths.—The daily addition of bleaching powder in the proportion of 1–10 parts of available chlorine per 1,000,000

will, apart from partially sterilising the water, deodorise it and prevent the formation of any slimy deposit.

Liquid Chlorine is obtainable in metal cylinders and special regulating manometers, *e. g.* the Wallace-Tiernan, may be used for its addition to water. It acts in the same way as bleaching powder, but is more compact (1 lb. of liquid chlorine = about 8 lbs. of bleaching powder), more constant and more easily controlled.

(*b*) **Excess Lime** has been advocated by Houston. The method consists in the addition to water of (1) sufficient quicklime to combine with the free CO_2 and any CO_2 present in bicarbonate combination, and (2) an excess dose of CaO amounting to about 1 part per 50,000. This will practically sterilise the water in from five to twenty-four hours. Thus with London water, 1 part of CaO per 5000 sterilised in from five to twenty-four hours; with Loch Katrine water, 1 part per 10,000 sterilised in five hours—experiments would have to be made to decide the amount necessary in any individual case. Any excess lime, remaining after sterilisation is complete, must be removed. This may best be done, after treating, say, three-quarters of the total supply by the excess lime method, by the final addition of the other quarter which has meantime been rendered safe by some other method such as storage, chlorination, etc. It would, of course, be possible to convert any excess lime into an insoluble carbonate by passing CO_2 gas into the water, but such a practice would add greatly to the expense. The process is harmless, cheap and reliable. It softens hard waters, and, if so desired, hardens soft waters. No storage reservoirs of any size are required and it is applicable even to flood waters from rivers.

(*c*) **Ozonisation.**—Ozone (O_3) has one atom of O available for oxidation purposes. About 1·6% ozone is obtained from dry atmospheric air, at a temperature between 20° and 30° C., by means of a silent high-tension electrical discharge. In the de Frise system this ozonised air is passed into a pipe conveying the water to the bottom of a water-tower, and, as the water ascends, it is continually mixed with the ozone by means of baffles. Any residual ozone is recovered from the air at the top of the tower and used again. After a short interval in a three-compartment tank, no taste is perceptible. The best ratio of water to ozonised air is 100 : 40. The water must be filtered first if turbid. Excellent results are obtained, as in Paris, where B. coli are usually absent in 500 c.c. of the treated water.

(*d*) **Ultra-violet rays** are germicidal without any chemical change apparently taking place in the water. The rays are given out by a transparent quartz mercury-vapour lamp, which should be encased in another quartz chamber, leaving a small

air space intervening. Thoroughly clarified water is made to pass slowly over the lamp by means of three baffle-plates. Should the lamp give out, the current of water automatically ceases. A lamp worked with a current of 3 ampères at 220 volts destroys pathogenic organisms within a radius of 2½ inches in two seconds.

Relative cost.—The chlorination and excess-lime processes are, of course, the cheapest, for, apart from any tank construction required, the only expenses incurred are the cost of chemicals and the wages of attendants. Prior to the war a mechanical filter cost a little more than £2000 per unit of 1,000,000 gallons, and the maintenance expenses were low. Open sand filters cost three or four times as much in the first instance. An ozonisation plant cost about twice as much as a mechanical filter and working expenses were greater.

PURIFICATION OF WATER ON A SMALL SCALE

(*a*) *Boiling* is a wise precaution to take before using any doubtful water. The portable Forbes Heat-exchange apparatus was formerly used in the U.S. army. In it the water is brought to boiling temperature and then cooled by the incoming cold water. The gases driven out by heating are reabsorbed before the water leaves the steriliser, thus obviating any flat and insipid taste.

(*b*) *Distillation.*

(*c*) *Treatment with chemicals*—

Bleaching powder.—Make a stock solution of half a teaspoonful of the powder in a pint of water. One teaspoonful of this will sterilise 10 gallons of water in about half an hour. The water should be rough filtered first.

Acid sodium sulphate.—A 2-gram tablet added to 1¾ pints of water will kill B. typhosus in fifteen minutes.

Potassium permanganate.—Add sufficient to render the water faintly pink for half an hour. This is used largely in dealing with suspicious wells during cholera outbreaks.

Precipitants such as sulphate of alum—6 grains per gallon—clarify the water and carry down most organisms in the sediment.

(*d*) *Domestic filters.*—Certain of these contain media of spongy iron, polarite, animal charcoal, sand, etc., in various combinations. They are not protective against pathogenic organisms, and serve only to clarify water or remove traces of iron. They give a false sense of security, and, if not frequently cleansed, they deliver water which is worse bacteriologically than the crude supply. Furthermore, pathogenic organisms retained in the medium may multiply and continue to infect the issuing water for days on end, the result being that the consumer runs more risk than had he drunk a raw water contaminated only on one occasion.

Berkefeld and Pasteur-Chamberland filter candles are hollow

bougies of specially prepared porcelain or Kieselguhr contained in a metal case and screwed to a water tap. Their delivery of water is very slow, but they are really germ-proof if scrubbed and cleansed in boiling water every three days. Without this precaution organisms may grow through the pores of the porcelain and appear in the filtered water. The porcelain must be absolutely sound, and union between the filter and the delivery pipe must be perfect. The Pasteur-Chamberland is rather more germ-proof than the Berkefeld. Both are unsuitable for turbid waters.

Distribution of Water.—Water is drawn from below the surface of storage reservoirs by means of a pipe, whose mouth is covered with a fine wire screen, and is led through open or closed aqueducts or pipes to the filter beds or other purification works. These pipes may be made of cast-iron, reinforced concrete, or steel if not too large a pipe is required. After treatment the water passes on to the service reservoirs. If near the town, these should be covered in and should be placed at such a height that water will rise about 20 feet above the highest house, in case of an outbreak of fire.

Cast-iron pipes should be treated by (1) Angus Smith's process, which consists in dipping the pipe in a cauldron containing a mixture of gas-oil and tar heated to about 400° F. After about half an hour the pipe is removed and drained. (2) Barff's process, where the pipes at white-heat are treated with superheated steam for several hours, with the production of a film of magnetic oxide of iron. By one or other of these means rusting or corrosion of the pipe is prevented for a considerable period and friction is also diminished. Cast-iron pipes are usually jointed with spun yarn and molten lead.

From the service reservoirs water is conveyed by more cast-iron pipes throughout the delivery area, the actual service pipes to the various houses being made of lead joined to the mains by screwed brass ferrules with soldered unions.

Water may be supplied either constantly or intermittently. In the latter case, after running for a certain number of hours, the supply is shut off every day. *A constant supply* is infinitely to be preferred. Strong fittings are required to withstand the continued pressure, all taps should be "screw-down," and there should be means of emptying water from the house-pipes in case of frost. It is alleged that there is great waste of water under this system, but with proper fittings and the use of modern means of detecting waste this is not such a serious matter. No water has to be stored in the house, drinking water can be obtained direct from the main, and plenty of water is available in case of fire outbreak.

"Water hammer" is due to too rapid closure of taps in a constant system. A compression wave is set up which travels

from the tap along the pipe to the main and back again. It subjects the pipes and fittings to great strain.

Intermittent supply.—The only possible arguments in favour of this system are that it lessens the chance of waste, and that cheaper fittings can be used. Against this must be set—

(1) Water has to be stored in houses, and insufficient and unsatisfactory arrangements usually exist for so doing. (2) It favours corrosion of the pipes. (3) If drains and water mains are laid side by side in the same trench, sewage may be sucked into the water-pipes during intermission of the service, if both pipes are defective. This, however, may happen even in a constant service if the pipes are faulty, but the chances are less. (4) It causes delay in extinguishing fires.

Whatever system is adopted, arrangements should be made in the delivery area to keep water constantly moving. There should be as few "dead ends" as possible, and these should be provided with scour valves.

Cisterns.—These are necessary in the intermittent system. In the constant system they are required only for feeding the kitchen boiler, and perhaps the waste water preventer in the water-closet.

Requirements.—A cistern should be made of slate, stoneware or galvanised iron. The latter tends to give up a little zinc to water, but in small amounts this can be neglected. Lead should not be used. There should be an overflow pipe, which must be of sufficient size and must discharge in the open air. Its situation should be accessible and well ventilated, and it should have a properly fitting cover. It must never supply the water-closet pan direct. It should be cleaned out every three months.

Solution of Metals by Service Water.—Certain waters act on metals with the result that these may be dissolved in varying amounts. The accepted standards are that a potable water should not contain more than $\frac{1}{20}$ grain of lead, $\frac{1}{15}$ grain of copper, or $\frac{1}{4}$ grain of iron per gallon. More than $\frac{1}{4}$ grain of iron per gallon can be detected by taste. Zinc is found in many drinking waters, and a limit of $\frac{1}{10}$ grain per gallon has been suggested, but it is certain that waters containing much larger amounts than this can be drunk over long periods without any harm resulting. (*The Lancet*, June 30, 1917.)

Plumbo-Solvency.—The solvent power depends on acidity and the presence of dissolved oxygen in the water. Waters that react acid to lacmoid are all potentially dangerous. Peaty waters are the worst offenders. Acidity in these is due to bacterial action on peat with the production of organic acids. Acidity is greatest when a wet spell follows a period of drought, and the first washings tend to be excessively acid. This may result in a reservoir getting such a large dose of acid water that it remains acid for a long time afterwards. Houston states that 1 part of peat will render plumbo-solvent more than

100 parts of water. Mineral acids cause less plumbo-solvency than do peaty acids. Soft waters are sometimes said to be plumbo-solvent. This is due to the fact that most large supplies of soft water are derived from moorland and possibly acid sources. Hard waters which deposit a layer of carbonate in pipes are protective. The action is due to the formation of an oxyhydrate of lead on account of the presence of dissolved oxygen in the water, and its subsequent solution in the acid medium. In plumbo-erosion, a loose deposit of insoluble oxyhydrate of lead is formed on any bright surface of the metal by the dissolved O in the water. This is carried away in the flow, and another bright surface is left for further erosion. In the absence of acidity there can be no solution of the lead. Erosion is of more danger to the pipes than to the consumer of the water.

Small amounts of lead may be dissolved by electrolytic action, through passage of an electric current, *e. g.* from the electric-lighting wires in a house, along a lead water-pipe.

The plumbo-solvent power of a water is estimated by its effect on lead shot.

Treatment.—(1) Endeavour to cut out the more acid feeders in the catchment area, and arrange to keep out of the reservoir the first washings after a period of drought.

(2) Various chemical methods have been tried, all of which aim at the reduction of acidity, *e. g.* addition of soda, milk of lime, or chalk, or filtration through lime-stone. In the latter case the lime-stone soon gets coated with a layer of vegetable matter and ceases to be efficient. The most popular treatment is the addition of chalk, and the case of Wakefield may be instanced. There, one grain of chalk per gallon is added—a larger dose would tend to clog the filters. Sand filtration follows this, and finally another two grains of chalk per gallon are added. The treatment gives excellent results.

(3) As a last resort, replace lead pipes and fittings with wrought-iron pipes, blocked-tin lined or glass-lined lead pipes. The two last are not very satisfactory, and are expensive. A lead pipe lined with block-tin is apt to have galvanic action set up between the two metals. It is said that a pipe made of an alloy of lead with 3% tin gives up no lead to water. Domestic filters made of animal charcoal, spongy iron, or polarite tend to remove lead in solution from a water.

Finally, the peaty slime that coats the inside of water-pipes may be plumbo-solvent, even though the water itself has ceased to be so. An endeavour should be made to remove this. The best plan is, of course, to filter the water thoroughly in the first instance.

DISEASES ASSOCIATED WITH WATER

(*a*) Due to inorganic salts: Diarrhœa, and gastric disturbance

from consumption of water containing excessive amounts of sulphates, etc. Poisoning from lead or other metals.

(*b*) Due to vegetable matter: Diarrhœa and gastric disturbance from excessive amounts of vegetable matter.

(*c*) Due to organic matter generally, *e. g.* entrance of sewage into water mains. Diarrhœa (*vide* L.G.B. (P.H.) Report, No. 108, 1915).

(*d*) Due to specific organisms: Enteric fever, cf. Guildford in 1867, Sherborne in 1873, Worthing in 1893, Maidstone 1897, Rhondda and Lincoln in 1904, Basingstoke 1905.

Dysentery, both bacillary and amœbic, and paratyphoid fevers.

Cholera, cf. the celebrated case of the Broad Street pump, Soho, in 1854, and Hamburg 1892.

Diphtheria (doubtful).

Anthrax, from washings from tan-yards.

(*e*) Due to some undetected poison (?) bacterial: Goitre—McCarrison in 1911 showed that the toxic substance exists in suspension in water and can be destroyed by boiling.

(*f*) Due to parasites: Ascaris, oxyuris, whipworm, ankylostoma duodenale, dracunculus medinensis, filaria, flukes, leeches, bilharzia, tapeworm ova, etc.

(*g*) Due to breeding of mosquitoes in water: Malaria and yellow fever, etc.

Features of an Outbreak of Typhoid Fever due to Contaminated Water Supply.—(*a*) "The period of invasion" usually lasts about one month. During this time a few cases will be notified. It is to be remembered that the incubation period occupies ten to fourteen days, and a certain number of days or even weeks may elapse before the case is finally diagnosed.

(*b*) "The period of explosive outburst" lasts from two to three weeks. Many people are infected simultaneously. This is very characteristic.

(*c*) "The period of secondary infection" may drag on indefinitely. Most cases are infected from existing sufferers, but a certain number of primary cases contracted from the water will still occur. Inquiry will show that, in the early stages of the epidemic, it is only those who have used the infected water who have suffered, and evidence will usually be forthcoming of persons developing the disease outside the infected area, who visited the area during the period of infection and consumed water while there.

Emergency measures.—Advise every one concerned to boil all water before using it for drinking, washing dishes, etc. Sterilise the water supply, and the water mains, with a solution of bleaching powder.

Ice is liable to the same contamination as water, and is often prepared and handled in a very unsatisfactory manner. Typhoid fever has been traced to infected ice.

SECTION II

REMOVAL AND TREATMENT OF WASTE MATTERS

THE REMOVAL AND TREATMENT OF SEWAGE

SEWAGE consists of solid and liquid human excreta, all waste water from dwelling-houses, trade wastes in manufacturing districts, and usually rain water and road washings.

An adult passes on an average about 4–4½ oz. of solid fæces (not water-free) and 50 oz. of urine per day. In a mixed community these amounts may be taken as 2½ oz. and 40 oz. respectively. The remaining liquid portion of the sewage amounts roughly to the water supply, though some of this is lost and does not find its way to the sewers, if such exist. The strength of a sewage depends largely on the water supply reckoned as so many gallons per head per day. It is obvious that a community with a water supply of only 5 gallons per head per day will yield a sewage of much greater concentration than another community with a supply of 30 gallons. Upon the quantity of sewage to be dealt with depends the system of disposal to be adopted. In districts where the water supply is small conservancy methods prevail, where the supply is large proper sewerage schemes must be undertaken.

Conservancy System.—This means the retaining of human excreta in or near the dwelling, with removal as frequently as possible. Some means, of course, must be adopted in addition for getting rid of waste waters.

DISPOSAL OF EXCRETA BY CONSERVANCY METHODS

Privies are closets where the excreta are received in a fixed receptacle of such size that a weekly removal of the contents is necessary. Such conveniences are placed usually in the back yard of a dwelling-house, and model byelaws have been issued regarding their construction (see p. 269). A privy-midden is a modification of the privy found usually in country districts. In it the closet seat is placed above a hole in the ground or partially bricked-in space, which serves not only as a receptacle for excreta, but as a dumping-ground for all sorts of objectionable filth as well. Privies of any sort are insanitary, and their abandonment is urgently necessary on public health grounds.

Earth Closets are the least objectionable type. In them the

receptacle may be either fixed or movable (pail). At least half a pound of dry earth should be used to cover each motion. This earth may be applied either by hand scoop, or by a hand lever or an automatic seat-action from a reservoir above. The best earth to use is good garden loam. It must be carefully dried before use. This earth acts in the first instance as a deodoriser, and if well mixed with the fæces ensures complete disintegration. In the Bedfordshire system, as employed in country schools, earth closets with pails are in use, earth being applied automatically by seat-action. A two months' supply is required in the first instance. When the pails are about two-thirds full,

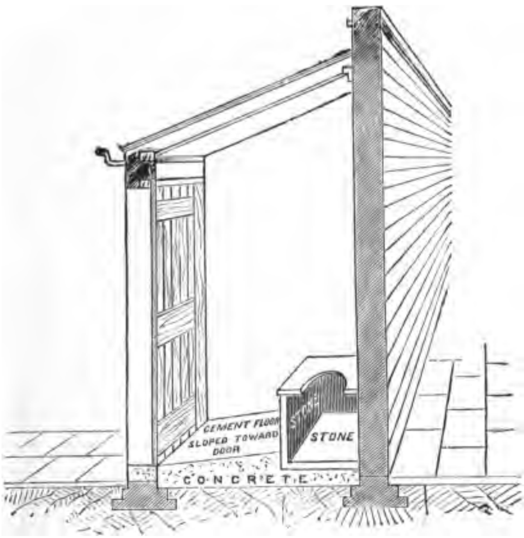

FIG. 4.—A privy constructed so as to comply with the model bye-laws.

the contents are deposited in small heaps, on a layer of dry earth, on the floor of an adjoining outhouse. The heaps are covered with more earth, and at intervals of a few days the whole is turned over and allowed to dry. Paper is raked out and burned, and in from one to two months the mixture is passed through a half-inch sieve and is ready to be used again. Instead of pails, a sloped and drained cemented surface may be used to receive the excreta beneath the seats. The system is made thoroughly proof against flies.

Pail Closets are really privies with a movable receptacle, and must conform with the same regulations *re* site, etc., as privies. Metal pails or tarred wooden tubs of a capacity not exceeding 2 cubic feet receive the excreta. Frequently fine household

ashes or sawdust may be used to cover the fæces in the manner described under earth closets. In the Goux system absorbent material such as stable litter is placed in the pails prior to use. Pail contents should be removed at least once weekly. This method was used largely by the Army authorities during the recent war, and, under careful supervision with daily emptying, worked fairly well.

In all these systems waste waters must be excluded from the closets, and it is advantageous, if possible, to keep out urine as well. The drier the contents the more readily is offence minimised, and the more easily is subsequent disposal carried out.

Disposal of Receptacle Contents

(*a*) *Digging into the Land.*—A suitable area of loamy soil should be selected, the excreta placed in trenches about 9 inches deep, and covered with 3 or 4 inches of earth. Such a trench, 8 feet long and 7 inches wide, will take the daily excreta of 100 men. Under suitable conditions the same patch of ground may be used over and over again at intervals of a few months. Even pieces of paper become disintegrated in the course of time.

(*b*) *Burning.*—This was the method adopted in the Army during the war. One small Horsfal destructor was capable of dealing with the excreta of 1000 men, together with dry camp refuse, with the aid of half a hundredweight of coal per day.

These conservancy systems are practised usually in small country villages, but in some of our large cities privies and pail-closets still remain. For the removal of the contents on a large scale special carts must be supplied, and as frequent rounds as possible should be made. Wherever a proper water supply and sewers are available there should be no excuse for retaining excreta in the neighbourhood of houses. In addition to causing a high death-rate from enteric fever and other diarrhœal diseases, conservancy systems have actually been proved to be more costly in the long run than the substitution of water carriage. Privies should invariably be abolished, pail closets are, perhaps, best when communal arrangements permit of a very frequent removal of contents, otherwise earth closets, if carefully attended to, will give the most satisfactory results.

(For Model Byelaws, see p. 269.)

Disposal of Waste Waters under Conservancy Systems

In large towns, of course, arrangements must be made for the proper removal of waste waters in sewers even though no water closets are provided. In isolated country districts the practice is usually to distribute these wastes on garden land. Each cottage, as a rule, disposes of its own waste water, unfortunately only too often by running it into the nearest ditch, which soon

becomes an evil-smelling nuisance in dry weather. The most satisfactory method is to run the water through a series of 3-inch agricultural porous drains, placed at a depth of about 6 inches under the surface of a plot of grass, or at a slightly greater depth in a tilled portion of the garden. This is better than distributing it over the surface. A strainer of some sort should be placed at the house end of the drain to remove articles that might otherwise block the pipes. Insufficient attention is paid to the disposal of such waste waters in most country districts.

The Cesspool System.—All cesspools should be water-tight, made of 9-inch brickwork rendered with cement, and surrounded at the sides and bottom with puddled clay 6–9 inches thick. A cesspool should be placed at least 50 feet distant from the house and 60–80 feet from a well or stream. In any case, should the local water supply be derived from shallow wells, the flow of the ground water should invariably be from the well towards the cesspool. A domed roof should be provided and a proper ventilating shaft attached. An opening should be left (with cover) for periodic removal of the contents, and frequently a pump is fixed. House drains are laid down to the cesspool exactly as though the cesspool were a sewer, and a proper ventilated intercepting trap should be placed at the cesspool end of the drain. In a small house with a not too generous supply of water an impervious cesspool may be made to take all the excreta and waste waters. Periodic removal of the contents is necessary. This is usually done by pumping them into a special cart with final disposal on land. In the case of a big house with abundant water supply the largest cesspool would be rapidly filled and the cost of frequent emptying would be considerable. There can be no objection, if the house has a good area of ground attached and there is no risk of contaminating water supplies, to providing an overflow pipe to the cesspool and running the cesspool liquid either below the surface of specially prepared land or over a proper filter bed. It may also be applied to freshly dug ground, but if run on grass land the grass is apt to be "burned" on account of the strength of the fluid. In all cases rain water should be excluded and utilised for domestic purposes.

No cesspools should be tolerated in towns, and cesspools made leaky, either through careless construction or with intent, are always a grave menace to water supplies.

WATER-CARRIAGE SYSTEM

Under this system houses are provided with a main drain, part of which is below and part above ground. The latter portion is known as the soil pipe. Inside the house the only drain openings allowed are the discharge pipes of water-closets, slop-sinks and urinals, and all such pipes must be trapped. Waste-water from kitchen sinks, baths, lavatory basins and rain

gutters must enter the drain only through special trapped gullies situated in the open air. The only trap in the direct line of the house drain between the sewer and the top of the soil pipe is the intercepting trap, shortly to be described.

A trap, in its simplest form, is a pipe bent on itself in such a way as to retain a certain amount of water in the bend. That portion of water which prevents the passage of gases from one side of the trap to the other is known as the "seal."

The requirements of a trap are—

1. Made of hard, smooth and impermeable material.
2. Self-cleansing.
3. Simple in construction.
4. No movable part.
5. No angles or corners.
6. A water seal of about 2 inches.

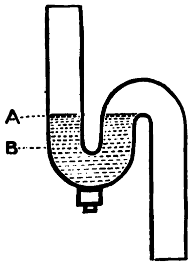

Fig. 5.—Syphon trap, with screw-plug for cleansing. A B, water seal.

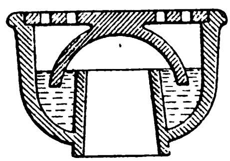

Fig. 6.—Bell trap.

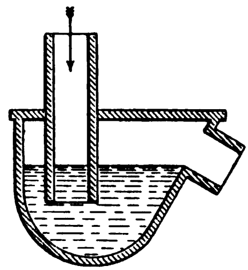

Fig. 7.—D trap.

The "intercepting" or "disconnecting trap," that is, the trap which disconnects the drain from the sewer, shall, in addition, have—

1. Its outlet lower than its inlet by about 3 inches.
2. Its inlet vertical, and its outlet proceeding upwards at an angle of 45°.
3. A raking arm with a tight-fitting cover.

The advantage claimed for this trap is that it does "disconnect" the drain from the sewer. By virtue of its position it completely intercepts the sewer gases, thereby preventing their passage from the sewer to the drain. The disadvantages, however, are many. By its abolition the problem of sewer ventilation would in all probability be solved, or at least very considerably simplified. It increases the liability of blockage, as obviously any bend in a drain favours the lodgment of solid matter. It almost invariably contains foul material, which

seldom gets flushed out with clean water. The cover to the raking arm is occasionally left out, or so loosely placed in position that it drops out, or gets blown out by the pressure of the gases emanating from the sewer. In the event of this happening, the trap no longer fulfils its requirement, as the sewer gases can now gain access to the drain. Moreover the cover falling into the half-open channel pipe of the man-hole is apt to block this pipe.

Where there is no man-hole, Buchan's intercepting trap may be employed as an alternative, the supply of fresh air for ventilating purposes being provided for by carrying a shaft from the house side of the trap to above the ground level (Fig. 8).

The "S," "P" and "Anti-D" traps are usually regarded as good types, the "D," Bell and Dipstone traps as bad. The "S" and "P" are simple double bends in a vertical plane, the difference between them being that the outlet of the "P" is nearly horizontal, and that of the "S" is vertical. The

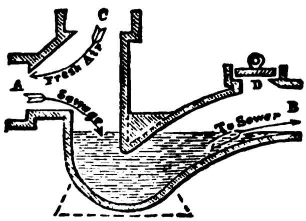

FIG. 8.—Ventilating, intercepting trap.

A, Socket for house drain. B, Connection with sewer.
C, Socket for fresh-air inlet pipe. D, Cap for clearing purposes.

"Anti-D" is a "P" trap in shape with a square outlet. This may be considered a defect, as any angle is apt to get rounded off by the accumulation of solid matter. But, as is pointed out later, this is counterbalanced by the advantage which it has of preventing unsealing by momentum.

The "D," Bell and Dipstone traps are now obsolete. The dome and the grid of the Bell trap are in one piece. The seal is that amount which the dome projects downwards into the water, hence by removal of the grid the seal is broken. This illustrates the necessity of having no movable part in a trap. See Figs. 6, 7.

Traps may get unsealed by: (*a*) evaporation, (*b*) suction, (*c*) momentum, and (*d*) compression.

(*a*) This can only be obviated by flushing.

(*b*) Where two or more traps discharge into one main pipe, as in the case of several water-closets discharging into a soil pipe, the flushing of one is liable to unseal the traps of those below. This is occasioned by the fact that the passage of the

water down the soil pipe has an aspirating effect upon the water in the traps lower down. To obviate this a pipe with a 2-inch bore is inserted into the pipe which leads from the water-closet trap to the soil pipe. These anti-siphonage pipes, as they are called, are connected to a main which runs upwards parallel with the soil pipe, in which it may terminate at a point above the highest water-closet, or it may be quite separate and distinct.

(*c*) If a large volume of water is suddenly thrown down a trap, the force may be sufficient to leave the trap unsealed. This may be avoided by the introduction of the "Anti-D" trap. The change in the shape of the pipe from a round to a square so increases the frictional area that the velocity of flow is impeded, with a consequent diminution of force, which leaves the seal intact.

(*d*) In the case of an unventilated drain, the pressure of the gas resulting from a collection of decomposing material may be sufficiently great to force the trap, as a 2-inch seal of water constitutes the point of least resistance. It is obvious that the only remedy is to ventilate effectually the drain, and to see that the drain is so constructed that no accumulation of material can occur.

The requirements of a water-closet—

1. It should be made of hard, smooth and impermeable material.
2. Of a "wash-down" pedestal form, from 12 to 18 inches high, and provided with a hinged seat.
3. Vertical posterior wall.
4. A flushing rim, and "after-flush."
5. The trap and pan made in one piece.
6. The "S," "P" or "Anti-D" trap only permitted. The "D" trap not allowed.
7. A water seal of 2 inches.
8. The "water waste-preventer," or flushing cistern, shall be siphonic in action, the overflow pipe of which shall in no way connect with any pipe, but shall discharge in the open air, thus acting as a warning pipe.
9. The flush to consist of at least 2 gallons of water, delivered from a height of not less than 4 feet. The discharge pipe to have an internal diameter of 1¼ inches, and to be as free from bends as possible.
10. The closet itself shall have at least one external wall, in which shall be placed a window 2 square feet in area, half of which must open. It shall be permanently ventilated by means of air bricks or grids.

In Figs. 9, 10, 11 and 12 various forms of water closets are given. If these are viewed in the light of the above-mentioned conditions, it will be observed that Fig. 11 is the only one that can be considered satisfactory.

The "pan-closet" is very objectionable. The container B and the "D" trap invariably become coated with offensive matter. The trap is usually made of lead, which is liable to erosion and subsequent perforation. More often than not the drinking-water tanks supplied the flush direct, without the intervention of the "water waste-preventer."

With the "long-hopper" closet there is a spiral flush. The swirl of the water does not cleanse the sides of the basin, and very often the force is so great that the swirling motion is main-

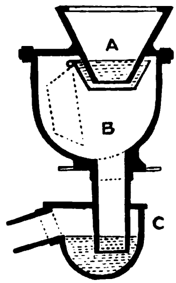

FIG. 9.—Pan-closet.
A, Basin; B, Container; C, D-trap.

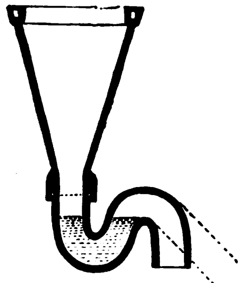

FIG. 10.—Long-hopper closet.

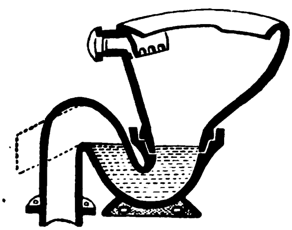

FIG. 11.—Short-hopper or wash-down closet.

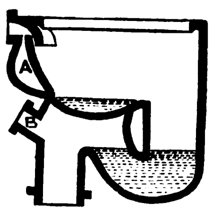

FIG. 12.—Wash-out closet
A, After-flush chamber;
B, Trap-ventilator.

tained right through the trap, thereby failing to remove the contents. It is evident that the soiling of the sides was intended. This is undesirable; all filth should fall free of the sides direct into the water.

In the "wash-out" closet the force of the flush is expended in passing over the weir; the water in the trap, therefore, is not "flushed" out. This also has the disadvantage of forcing the soil from the basin on to the pan wall, thereby fouling it.

The "siphonic" water-closet (Fig. 13) is one in which water is retained in the pan, and in a trap at a lower level. The flush is divided into two streams, one flushes the pan, and the other

is directed into the vertical pipe above the trap, expelling the air through the "puff pipe" just above the water level, thus starting siphonic action. The contents of the pan are in that way sucked through the trap into the soil pipe, as well as being flushed through. It is very effective.

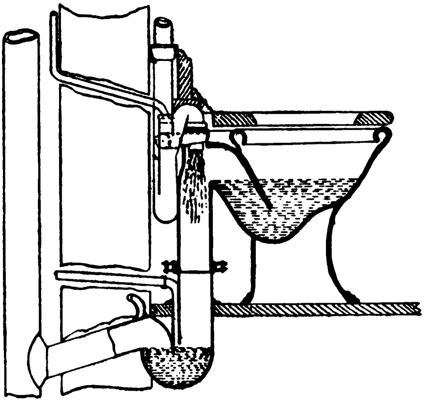

FIG. 13.—"Siphonic" closet.

The valve-closet and plug-closet are two types which are gradually being replaced by more modern patterns. With these, water is retained not only in the trap, but also in the basin by means of the valve or plug. This compels some provision being made for an "after-flush." They are not considered very satisfactory.

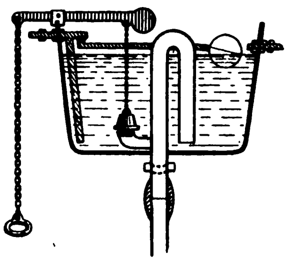

FIG. 14.—Waste-preventing cistern.

The siphonic "water waste-preventer" will be better understood if the diagram is consulted (Fig. 14).

When the chain is pulled, the plug is removed from its seating, and water is thus allowed to enter the descending arm of the siphon or the flushing pipe. This draws the water from the cistern over the bend, and starts siphonic action. The object of this particular pattern is to ensure that a 2-gallon flush is obtained. It is obvious that all that is required is a pull of the chain, when the tank will empty itself.

In order to economise water the "slop-closet" is sometimes employed. With this type the household waste water is used for flushing purposes. It consists of a seat placed over a large trap. The waste water from the house collects in a "tumbler" pivoted in such a way as to overbalance when full. The contents

are discharged very forcibly through a short drain, which terminates over the trap, the "tumbler" then swinging back to its original position. This type is not considered really satisfactory. It is installed only in the poorest class of property, and, where many are in use, the resulting sewage is so strong that it is difficult to treat. In addition the sewers suffer from lack of proper flushing. This "slop-closet" must not be confused with the slop-sink which is placed indoors in large houses or institutions and used solely for the emptying of slops.

Another form of closet, used more particularly in schools and factories, is known as the trough-closet. The seats of a series of closets are placed over a channel or trough filled with water. At intervals the trough is flushed out, as a rule automatically, the water passing over a weir into a trap beyond and thence to the drain or sewer. More improved trough-closets have been devised, where each seat has its own pan dipping just under the surface of water in the trough, and where each pan has a flushing rim connected with the automatic flush tank. The system is not a good one, however, as excreta accumulate in the trough in the intervals between flushes, and careless habits are apt to be acquired by persons using such a contrivance. This applies specially in the case of children.

A stoneware drain-pipe should be impermeable and well glazed. Its length is usually 2 feet, and its diameter either 4 inches, 6 inches, or 9 inches. One end is known as the socket, and the other as the spigot. The lower portion of the circumference is the "invert," the top is the "crown," and the sides are called "springings." Drains made of these pipes are usually employed for ordinary dwellings. They are, however, liable to fracture, and when laid in loose earth, or ground liable to erosion by water, they are apt to sag at the joints. In such a case iron pipes are to be recommended. These are made in 9 foot lengths, and the jointing is of metal. The risk of fracture, therefore, is very small, and the liability of sagging is considerably reduced. The disadvantage of rusting is removed by treating the pipes with some preparation such as Angus Smith's solution. All pipes should be laid with the spigot end pointing to the sewer.

To join stoneware pipes to each other cement is used. The spigot of one pipe is inserted into the socket of the other. Rope is then hammered down into the space between the spigot and the socket. This prevents movement, ensures the same thickness of cement in the joint, and guarantees a "true invert." Cement in a pasty condition is then poured in over the rope until the annular space is filled.

Iron pipes are jointed in the same way, with the exception that molten lead is used in place of cement. The lead is rammed down into the socket, the process being known as caulking.

To connect lead pipes, the end of the one facing the flow is

flanged out, when the other is slipped inside it. At a short distance away from the joint each pipe is painted with a mixture of lamp-black and size. This prevents the lead, of which the joint is made, adhering to the pipe. Molten lead is now poured on, and when in a semi-solid state it is "wiped" round the junction until the joint is effected.

Iron to stoneware may be jointed with cement, as in the case of stoneware to stoneware.

N.B.—Iron and brass will take cement, lead will not.

To join an iron pipe to a lead one, a brass collar or thimble is interposed. Between the iron and the brass a "caulked" joint is made, and between the brass and the lead a "wiped" joint.

Lead and stoneware can be satisfactorily jointed by the interposition of a brass collar. The brass to the lead is joined by the method already described, the connection between the brass and the stoneware being made with ordinary cement.

The soil pipe should be made of drawn-lead or iron with "caulked" joints. It should have an external position, be as straight as possible with no diminution in its size, and be carried well above the eaves of the roof. The top, which acts as a ventilating shaft, should be covered with a wire cage to prevent birds building their nests therein. A trap must never be placed at the bottom of the soil pipe.

The main drain should run as straight as possible to the sewer, and should rest on a solid layer of concrete. Wherever practicable the drain should not run under a house, but in the event of there being no alternative, then the drain should be surrounded by concrete 6 inches in thickness.

The velocity of flow should be about 3 feet per second. If this rate is exceeded, the solids are apt to be left behind on account of the rapidity with which the water runs away. To secure this rate of flow a fall of 1 in 40, 1 in 60, or 1 in 90 is required for a 4-inch, 6-inch, or 9-inch pipe respectively. The velocity depends, therefore, not only upon the gradient, but upon the size of the pipe, on the assumption that it is flowing full, and also upon friction, and impedimenta, such as cement projecting inwards from the joints.

Bath and sink wastes must be trapped. A screw should be placed at the bottom of the trap for cleaning purposes. The waste pipes should go straight through the external wall, and be carried down to discharge over a trapped gulley in the open air. Slop sinks, however, are an exception to this rule. As they are used for the disposal of urine and other waste water, they should meet with the same requirements as a water-closet.

Rain-water pipes should not be connected with any other pipe, but be led to terminate over a trapped gulley.

Surface water from yards should be conveyed by means of channels to a trapped gulley.

In large houses the gulley which receives the waste from the scullery sink is apt to get clogged by the solidification of grease. To prevent this, special gullies known as grease-traps are employed. The outlet of the trap dips below the surface of the liquid, and as the grease floats an unobstructed egress for the liquid is maintained. The grease may be removed by hand, or broken into small pieces and washed into the drain by a flush of cold water automatically discharged from a cistern provided for the purpose.

All gullies lead to branch drains, which should join the main drain obliquely and in the direction of the flow, and have the same requirements with regard to alignment, fall, velocity, etc.

Inspection chambers should be placed wherever one drain meets with another or changes its direction. The inspection chamber which contains the intercepting trap should be ventilated by means of a shaft carried up to some safe position above the ground level. As this shaft is intended to be an air inlet, the mouth is guarded by a mica flap, hinged in such a way as to permit air to enter only, thereby preventing the escape of drain gases. This provision allows fresh air to permeate the drain, the foul air escaping at the other end, that is, at the top of the soil pipe.

(Cf. Model Byelaws *re* drains, p. 272.)

DRAIN TESTING

This can be done by (*a*) smell test, (*b*) water test, (*c*) smoke test, and (*d*) pneumatic test.

(*a*) Oil of peppermint is poured down a trap which leads to the main drain, followed by a bucketful of hot water. If the drain is very defective, the scent of the peppermint will find its way into the house in the course of fifteen to thirty minutes. The person performing the test must exercise care in not contaminating any part of his person with the oil, as he would then carry the smell about with him. To prevent this possibility other chemical "testers" are now commonly employed. They consist of some powerful-smelling chemical, such as calcium phosphide, contained in a cap sealed with cement. When one is washed into the drain, the water dissolves the cement, thus liberating the chemical. This results in the evolution of phosphoretted hydrogen, the smell of which is very penetrating. The tester can be withdrawn from the drain by means of an attached string to see if the chemical has been discharged.

(*b*) The drain as it enters the disconnecting chamber is blocked up by a plug provided for that purpose. The drain is then charged with water up to the top of a trap which leads into it. A marked subsidence of the level of the water in the trap will indicate a leakage, and therefore a defect. Owing to the fact

that air might be occluded as the drain is being filled, it is advisable to place a length of rubber tubing down the trap to allow for the escape of the displaced air. The water should stand for one hour before an opinion as to the soundness of the drain is pronounced. In the case of a system where several drains are involved, each drain should be tested separately, or where the drain runs from manhole to manhole each section should be submitted to a separate test. When the drain is full of water, the pressure is unequally distributed, as clearly that section at the lowest level is subjected to a greater " head." This implies a test of varying severity—in fact, for old drains it is too severe. For the same reason it is inadvisable to test the soil pipe by means of water.

(*c*) With the smoke test the drain leading to the disconnecting chamber is blocked as before. Smoke is then pumped through a hole in the plug, or a lighted smoke rocket is inserted in the drain prior to plugging. When the smoke is seen to issue from the top of the soil pipe, proving that the smoke has permeated the whole length of the drain, this is also plugged. Pumping is continued until the smoke is under pressure. If any smoke is seen to escape, the drain is defective. The smoke machine used for this purpose consists of a receptacle in which cotton waste or other suitable material is allowed to smoulder. By means of a bellows attachment the smoke is pumped from the receptacle through a pipe which is connected with the drain plug. There is no need to plug any trap leading to the drain, as the seal of water is usually sufficient.

(*d*) With the pneumatic test, all openings are blocked up, and air is pumped into the drain until a certain pressure is indicated on the dial of the machine. If this pressure is maintained the drain is sound. Owing to leakages which might occur either in the machine itself or its connections with the drain the test is unreliable.

SEWERS

Modern sewers are made to convey all household effluents, trade wastes, water used for municipal purposes, and rainfall. They should be quite impermeable, but, in the original designs, the sides were purposely made porous in order to assist in carrying away the sub-soil water. This is undesirable as, obviously, sewage can also escape through the walls, and pollute the surrounding ground and ground-water. Sometimes provision is made to drain the soil by leaving a space under the sewer, or by resting the sewer on hollow blocks through which the sub-soil water can pass. In some places the rainfall is excluded from the sewers, a separate system of drains being provided for carrying the rain-water to a river or other watercourse. The pipes for

this purpose may be porous, thus rendering them available for draining the soil. The "separate system," as it is called, has some advantages. Owing to the exclusion of the rain-water, the sewage received at the sewage works is more constant in quantity and quality. This simplifies the method of purification and disposal. On the other hand, the sewers lose the cleansing effect of storm waters, and these waters are often so very foul, more particularly the first washings of the streets, that the river into which they discharge is dangerously contaminated. Again, owing to the fact that a double set of pipes is required, wrong connections occasionally are made.

Sewers are made of glazed stoneware, concrete, iron, or bricks. The sizes vary from about 12 inches to 12 feet. The smaller ones are usually of glazed stoneware, laid and joined in the manner described under house drains. The medium-sized are either of concrete or iron, the latter being protected from rusting by Angus Smith's method. The large main sewers are almost invariably made of bricks, rendered with cement. The shape is in accordance with the size. The smaller are egg-shaped or oval, and the larger ones round, in order to secure the greatest flowing area. As the wetted perimeter decreases more uniformly with a lessened flow in the case of the oviform type than with the round, the former tends to be the more self-cleansing.

The fall should range from 1 in 200 to 1 in 800 according to the size. The smaller the sewer the steeper the gradient. The velocity should be between 2 feet and 3 feet per second. Although it is desirable to remove the sewage as expeditiously as possible, an excessive velocity tends to wear away the "invert," by the action of the road detritus which gains access to the sewer. Manholes for inspecting and flushing purposes should be placed at every change of direction and gradient, or at intervals of 100 yards.

Drains or tributary sewers should join the main sewer, obliquely and in the direction of the flow, and in such a way that the sewage does not "back up" into the small pipe when the larger one is flowing full.

Sewers may be flushed by means of tanks, which should be automatic if the sewer has not a sufficient gradient. For this purpose Roger Field's "Annular Syphon Tank" is commonly employed. In this tank when the water overflows the descending arm of the syphon, it is deflected to the centre of this tube by means of a lip projecting downwards and inwards. Thus some of the air confined between the water in the cistern and that of the trap is removed, as water in the act of falling entangles air. This process is repeated until such a rarefaction of air has occurred that syphonic action is set up, and the cistern empties itself.

Flushing may also be effected by gates which temporarily

dam back the sewage, until such a volume is collected that the gate is swung to a horizontal position, thus allowing the sewage to escape with great force. Occasionally large volumes of water are discharged into sewers by hose-pipes. The cleansing effect of rain-water must not be lost sight of.

Ventilating openings should be provided in order to avoid the risk of the house traps being forced by the pressure of the sewer gases. These openings should lead from the crown of the sewer to the top of the camber of the road. Deodorisers such as charcoal have been placed in these openings, but have been found useless in practice. Where the streets are narrow it is safer to carry the shafts up above the ground level to a height far removed from any window. Tall factory chimneys have been utilised to aspirate air from the sewers. The vent pipe from the sewer terminates in the chimney, thereby taking advantage of the ascending current of warm air. Another similar device is to allow hollow lamp-posts to act as ventilating shafts. The gas flame tends to create an upward current, and also to destroy the effluvia. The ventilation of sewers is really due to various physical facts. In winter the sewer air is warmer than the outside air, in summer it is colder. Sewer air is also moister, therefore lighter, and consequently it tends to rise. In that way a continuous diffusion of air is taking place between the sewer and the outside. The ventilating shafts are simply means to allow this interchange of air to occur. Variations in the volume of sewage expel or suck in air. Other factors concerned in sewer ventilation are sudden changes of barometric pressure, and the aspirating effect of the wind blowing across the top of the ventilating shafts.

In the case of low-lying and flat districts, where a sufficient fall for the sewers cannot be obtained, and where difficulties arising from unequal levels have to be overcome, Shone's pneumatic ejector for raising the sewage has several advantages. It seldom gets out of order, as very little mechanism enters into its construction, and the solids falling to the bottom of the tank are removed first, followed by the liquid portion of the sewage. The motive force is compressed air. Air is compressed at a central station, from which it is conducted by special pipes to the ejectors placed at the required positions. The ejector itself consists of an air-tight tank into which the sewage gravitates. In the process of filling a cup is raised, and when this reaches the top of the tank, the valve controlling the compressed air is opened. The admission of the compressed air drives the sewage through an outlet at the bottom of the tank, and thence through a vertical pipe to a sewer at a higher level. The inlet and outlet to the tank are provided with valves in order to prevent the sewage flowing in a direction reverse to that which is required.

According to the early experiments of Parry Law and Andrews, sewer air is sterile, or at least free from bacteria of sewage origin. This view, however, has undergone modification. The more recent work of Horrocks shows that, even with smooth-flowing sewage, micro-organisms may be present. This has been confirmed by the subsequent researches of Andrews. Bacillus coli communis, streptococci, and, in one instance, B. typhosus, have all been isolated. The organism used for experimental purposes was B. prodigioses, as this organism is easily recognised and has distinct cultural characteristics. It was added to the sewage and recovered from the air. These experiments also proved that the disconnecting trap prevents the bacteria present in sewer air passing into the house drain. They also tend to revive the opinion once held of the conceivability of such diseases as typhoid fever and diarrhœa being communicated by drain and sewer air. When drying of the crown and sides of the sewer takes place, bacteria are detached. The sewage during its flow undergoes partial decomposition, resulting in the formation of bubbles, which in the act of bursting create a fine spray. Minute drops also are ejected into the air when splashing occurs. In these ways we can account for the presence of bacteria many feet above the flowing sewage. The same applies to drain air, as much agitation and splashing occur when the contents of a water-closet are forcibly removed.

The chemical composition of sewer air is subject to considerable variations. In well-ventilated sewers the composition closely approximates that of outside air. It is dust free and there is usually a slight diminution in the amount of oxygen, with a corresponding increase of carbonic acid. In the case of badly-ventilated sewers or "dead ends," however, the oxygen content may be greatly reduced, and sulphuretted hydrogen may be present in such amount as to be actually poisonous.

A continued inhalation of drain and sewer air predisposes to a general loss of health, *e. g.* anæmia, headache, vomiting, sore throat, skin eruptions and diarrhœa. The exact cause of these conditions is difficult to determine. Possibly only a reduced vitality is produced, which renders the individual more susceptible to bacterial infection. Sewer men as a class are healthy, due primarily to the fact that only strong, robust men are selected for this work. Acclimatisation also probably plays a part.

DISPOSAL OF SEWAGE UNDER WATER-CARRIAGE SYSTEMS

1. **Discharge into the Sea.**—This method, which is the most economical of all, is practicable for coastal towns, provided the outlet can be carried sufficiently far from the shore and in such a direction that the prevailing wind and currents will not drive

the sewage landwards. The outfall should be below the lowest tide level, and should be protected with a valve to prevent sea water backing up the sewer. If the foreshore is very flat, tanks may have to be constructed to retain that portion of the sewage which would otherwise have to be discharged at low water. Many experiments with floats of various sorts have usually to be made prior to selecting a suitable spot for the outfall, and local conditions must be carefully studied. The possibility of infecting shell-fish layings must always be borne in mind.

2. **Treatment of Water-carried Sewage.**—When discharge into the sea is impossible, local authorities have to make some arrangement for the purification of their sewage. Whatever method is adopted, the final effluent must eventually run into a stream of some sort, and certain standards have been fixed which determine the degree of purification necessary. The Sewage Commissioners suggested that—

1. No sewage effluent should contain more than 3 parts of suspended solids per 100,000.

2. No sewage effluent should absorb more than 2 parts by weight of dissolved oxygen per 100,000 in 5 days at 18° C., and that the stream after receiving the effluent should not absorb more than 0·4 part in the same time.

Certain important exceptions were made depending on the size of the stream receiving the effluent.

1. When the stream is from 150–300 times the volume of the effluent, the standard of dissolved oxygen may be neglected, but the suspended solids should not exceed 6 parts per 100,000.

2. When the stream is from 300–500 times the volume of the effluent, solids in suspension should not exceed 15 parts. Ordinary sedimentation tanks would ensure this.

3. When the stream is more than 500 times the volume of the effluent, all tests may be neglected, and the only treatment necessary is screening to remove the larger solid matters.

The aim of the two tests recommended by the Commission is to gauge the putrescibility and de-aerating power of the effluent and the possibility of a stream becoming silted up by an excessive amount of solids discharged into it. Bad effluents in time cause a nuisance in the streams receiving them, the growth of sewage fungus is encouraged, and fish life endangered. As many of our towns draw their water supply from rivers, all precautions should be taken to prevent pollution whenever possible.

Before any particular form of treatment is decided on, local conditions must be thoroughly studied. The flow of the sewage must be accurately gauged by actual measurement (*e. g.* over a weir) and the average dry weather flow (D.W.F.) calculated. The variations in flow must be noted. These will be found to be quite considerable in certain localities, depending on whether

the town is a residential or a manufacturing one. The character of the sewage must also be determined. This can only be done by repeated analyses and by a study of any trade wastes that may be discharged into the sewers. Samples of sewage for analysis should be taken every hour for twenty-four hours on end, the amount collected at each sampling varying with the amount of sewage actually flowing through the sewer at the time. All these hourly samples are mixed, and an analysis made of a portion of the mixture. The following are analyses of sewages of various strengths—

	Parts per 100,000.			
	Very strong.	Strong.	Average.	Weak.
Free and saline ammonia	13·4	7·6	3·5	2·5
Albuminoid ammonia	1·75	1·4	0·9	0·6
Oxygen absorbed from permanganate in 4 hours at 80° F.	18·0	24·4	11·3	6·5
Chlorine	13·6	11·4	9·2	6·6
Solids in suspension	42·0	24·0	29·0	26·0

Sewage from a purely residential town with a good water supply is the easiest to treat, that from an industrial town or military barracks with a less generous water supply offers much more difficulty. The various data having been obtained, the next thing is to decide on the form of treatment most suitable, and to select an area of ground for the necessary works. Sewage should flow by gravitation to the area selected, as pumping to a higher level will add greatly to the cost.

The various requirements of the average purification works are—

A. Preliminary treatment common to all types.
   1. Arrangements for dealing with storm water.
   2. Screening.
   3. Detritus tanks.
   4. Tank treatment proper.
   5. Disposal of sludge.

B. Treatment of tank liquor.
   1. Land treatment or
   2. Artificial biological treatment.
      (*a*) Artificial filter beds.
      (*b*) Contact beds.

C. Deposit of humus in special tanks.

A. **Preliminary Treatment.**

1. **Storm Water.**—If a separate system of sewers has been installed, storm water will not have to be dealt with to any

extent, but as the combined system is by far the more general, provision has usually to be made for excessive flow of sewage during periods of rain.

The Sewage Commissioners laid down that an increase in the volume of sewage up to three times the dry weather flow should be dealt with in the works as ordinary sewage. Anything over three times and less than six times the D.W.F. should be run into special storm-water tanks capable of holding one quarter the D.W.F. The effluent from these tanks can be discharged direct into the main outfall from the works, as most of the suspended matter will have been deposited. Anything over six times the D.W.F. can be run off direct into a stream without any treatment. By an arrangement of weirs in the channel leading to the works from three to six times the D.W.F. is directed to the storm-water tanks, while anything over six times is run off without passing through any portion of the purification plant.

2. **Screening** is necessary to remove the grosser solids, such as lumps of fæces, pieces of paper, and various foreign bodies. As a rule, a screen made of vertical iron bars, about $\frac{3}{4}$ inch apart and leaning at an angle of 45° away from the flow of the sewage, is used, but certain automatic self-cleansing screens, driven by a water-wheel in the sewage channel, may be seen. These consist of an endless band of fine wire-mesh moving at an angle with the flow of the sewage. Screens should be cleansed frequently, if not automatic, and the screenings collected and disposed of daily, either by digging into a portion of land or by burning in a destructor if one is available. These screenings may amount to as much as 10% of the total suspended matter in the sewage.

3. **Detritus tanks,** or grit chambers, are usually placed immediately after the screens. They are small tanks arranged in couples, each tank being capable of holding about $\frac{1}{100}$ part of the D.W.F. Two tanks are necessary, as a daily cleaning is required—hence whilst one tank is having the solids removed from it, the other is in use. Grit chambers collect the heavier particles of mineral matter that get washed down the sewers.

4. **Tank Treatment Proper.**—So far only the more obvious solid matters have been removed. The sewage still contains much fine suspended matter that must be got rid of, especially if artificial filter beds form the next step in the treatment. The principal forms of tank treatment are—

(*a*) Chemical precipitation.
(*b*) Sedimentation.
(*c*) Septic tanks.
(*d*) Travis's hydrolytic tank.
(*e*) Dibdin's slate bed.

(*a*) **Chemical precipitation** is specially suitable when a tank liquor containing the minimum of suspended matter is required, and is particularly valuable where trade wastes, such as are discharged by breweries and tanneries, form a considerable bulk of the sewage. Under this process nuisance from smell is reduced very markedly. The main objection is that the amount of sludge or deposited matter in the tanks is increased, and the problem of getting rid of it is sometimes very difficult.

Various precipitants are used, the commonest being lime, alumino-ferric, or mixtures of lime and alumino-ferric or lime and sulphate of iron. The amounts vary considerably in different localities, a total quantity of precipitant of from 5–15 grains per gallon being common. These chemicals are usually added in solution to the sewage as it flows along an open channel. Automatic arrangements exist for so doing. If two chemicals are used, it is advisable to add one at a point slightly before the other. Thus, experience has shown that, if sulphate of iron and lime are employed together, it is well to add the lime first and the iron a few yards further on. Alumino-ferric is often laid in blocks in the channel leading to the tanks—the greater the flow of sewage the more chemical is dissolved. Some arrangement of paddles or baffles should always be placed in the channel to ensure thorough mixing.

At Kingston the A.B.C. process is worked. A mixture of alumino-ferric, blood, charcoal and clay is added in a proportion of about 50 grains to the gallon. The resulting sludge is dried and powdered and sold as "Native Guano" for manurial purposes.

In the tanks the sewage is either allowed to settle for two to four hours, or else is passed continuously through, eight hours being occupied in the process. In an ordinary domestic sewage a tank liquor containing not more than 6 parts of suspended matter per 100,000 should be obtained.

(*b*) **Sedimentation** or settling tanks.

1. Continuous-flow sedimentation means that the sewage is allowed to pass continuously through the tanks, settlement taking place all the while. If the tanks have a capacity equal to twelve hours D.W.F. of the sewage, then the sewage is said to have twelve hours continuous-flow sedimentation. From eight to twelve hours is the time usually allowed.

2. Quiescent sedimentation means that sewage is filled into empty tanks, which are then allowed to stand full from two to four hours, till most of the solids settle. By this method slightly more solids are deposited than by continuous flow, and, consequently, more frequent sludging is required.

The ordinary tank is a rectangular pattern, the ratio of the length to the breadth being about 3 to 1. The depth is greater at the inlet end than the outlet, as the floor is made with a fall

of about 1 in 30. An average depth of from 5 to 6 feet is common. The sewage flows into the tank over a sill extending the whole breadth of the tank, and flows out over a similar sill at the other end, but at a slightly lower level. In continuous-flow tanks scum-boards are usually placed at 3 or 4 inches from both sills and dipping about 18 inches under the surface of the liquid. These prevent floating particles from being carried through to the filters. In one bottom corner at the inlet end of the tank, to which the floor should be made to slope, is a pipe-opening closed by a hand-operated valve. This allows of sludge being run off periodically by gravitation. In addition some arrangement should exist for draining off the water lying above the sludge. When this is done workmen can then enter the tank, wash all sludge down the special pipe-opening referred to, and thoroughly cleanse the tank. Sludge from the various tanks should be run by gravitation through pipes to a central point at which it can be treated. Several smaller tanks are better than one large one, and it is a good plan to have at least two spare tanks, one to act as a relief when one of the others is being sludged, and the other as a stand-by in case of much increase in the flow during rainy weather. Occasionally tanks are worked in series, sewage flowing from one to the other. The important point is that the requisite number of hours of contact should be secured. Sludge should be run off when necessary, and in many places each tank is emptied and cleansed every three or four weeks.

The Dortmund tank is another form of sedimentation tank. It is really a cylindrical tank sunk in the ground and tapering to a point at the bottom. The apex is plugged by a hand-controlled valve. Sewage is allowed to enter through a pipe which passes vertically downwards through the centre of the tank to within a few feet of the bottom. By this means the upper layers of liquid are kept more or less quiescent, and the solids in suspension tend to deposit in the apex of the conical bottom. Before the sewage can finally escape, it has to pass through the quiet upper stratum. In ordinary practice in this country the outflow is by means of weirs leading to a channel encircling the tank. Sludging is carried out by releasing the valve at the very bottom of the cone. The weight of water in the tank forces the deposited solid matter through the opening and up a sludge pipe leading to some previously selected spot. Various modifications of this tank are in use in this country with satisfactory results.

(c) **Septic Tanks.**—This system was first introduced in Exeter in 1895. It consists of a roofed rectangular tank with both inlet and outlet pipes dipping some little distance below the surface of the liquid. In the course of time a thick leathery scum forms on the surface, below this is a clearer layer, and at

the bottom of the tank is a small deposit of fine organic matter. All mineral solids should be separated by a grit chamber before the sewage is allowed to enter the tank. A continuous-flow method of working is adopted, and the time of contact usually recommended is not more than twenty-four hours or less than twelve hours. Hence tanks capable of holding one day's D.W.F. should be constructed. It is not necessary to roof over the tanks, as the scum that forms after a short period of working forms a sufficient covering. The importance of this preliminary liquefying anærobic treatment was insisted on by Cameron, the originator of the method, and it was maintained that such a tank effluent would contain no pathogenic organisms, and would yield readily to subsequent ærobic nitrifying treatment on filters, and, furthermore, that no sludge would remain behind in the tank. While satisfactory results may be obtained, especially where domestic sewage is concerned, the septic tank has not given generally any better results than other methods of treatment. Sludge accumulates in septic tanks just as it does in sedimentation tanks, and the tank liquor is just as troublesome to treat. As a matter of fact, the boundary line between septic-tank and settlement-tank treatment is ill defined. Both tanks are nowadays made on exactly the same plan, and the main difference appears to consist in the fact that the sewage is allowed a slightly longer contact in septic than in sedimentation tanks. Sludging is less frequently practised, and a little sludge is always left in the bottom of the tank to restart the anærobic bacterial process. Care must be taken not to disturb the scum.

(*d*) **Travis's Hydrolytic Tank.**—In tank treatment, suspended solids tend to be broken up and a certain amount passes into colloidal solution. This transformation, Travis maintained, is the result of physical action much more than bacterial. The change from colloidal solution to actual solution can also be brought about by the same means. Travis constructed a tank in which the sewage was given a huge area of surface with which to come in contact. This surface was secured by placing in the tank large numbers of strips of wood held in vertical position by special frames. On these strips solids were gradually deposited, and in the course of time dropped to the bottom of the tank and were removed from there through special valves. The system is expensive and has not found great favour.

(*e*) **Dibdin's slate bed** is midway between tank treatment and contact bed. It consists of a rectangular tank filled to a depth of 3 feet with horizontal layers of slate, each layer being separated from the next by small blocks of slate about 2 inches in thickness. The bed is filled with crude sewage, allowed to stand full for a varying length of time, then emptied, and finally allowed to rest empty for some hours. This implies that ærobic treatment is of more consequence than anærobic in the process

of liquefaction of the solids in sewage. In the course of time the layers of slate get coated with fine earthy material, and very little sludge is said to be left behind.

Of all forms of tank treatment, that most commonly in use in this country is continuous-flow sedimentation with a period of contact of eight to twelve hours.

5. **Sludge.**—Whatever tank is selected, arrangements must always be made for dealing with the sludge deposited in it. Where chemical precipitation is employed the problem becomes more difficult. As a rule, sludge, as it is run off from a tank, contains 80–90% of moisture. Of the solids present about half are mineral and the other half organic. It may be said that in chemical precipitation sludge will amount roughly to 30–40 tons per million gallons of sewage, in sedimentation 15–20 tons, and in septic tank treatment 10–15 tons.

Disposal of Sludge

(*a*) In the sea—as in London and Glasgow.

(*b*) On land. The best method is burial in shallow trenches. It may also be run over recently-ploughed land and allowed to dry, but difficulty occurs in wet weather, and a good deal of nuisance from smell arises.

(*c*) Lagooning, that is, running the sludge over specially prepared surfaces, where it lies till it loses most of its moisture, when it may be sold or given to farmers for manure. Wet weather frequently renders this method more or less useless, and unless the area is isolated the smell is likely to cause nuisance.

(*d*) Sludge-pressing by special machinery will remove from 30–35% of moisture. The resulting cake, as it is called, is easily handled. It may be given away as manure, burned in an incinerator, or used for filling in waste land that is not likely to be used for building for many years to come.

In certain districts where sewage contains a large quantity of grease, as, for instance, in Bradford, arrangements exist for recovery of grease from the sludge by various chemical processes. If sulphuric acid is first added, and then superheated steam blown through the sludge, the fat will rise to the top of the mass and can readily be removed.

B. **Treatment of Tank Liquor.**

In the huge majority of cases this tank liquor will require further treatment, although in certain instances, when the volume of the stream receiving the sewage effluent is very much greater than the effluent, further treatment may be dispensed with (p. 36).

1. **Land Treatment.**—If plenty of land is available at reasonable cost, this will probably give the most satisfactory results. If suitable land can be purchased at £100 per acre land treatment is probably cheaper than artificial treatment, and, if

properly worked, good land will produce an effluent containing fewer suspended solids than any other process. The best soils are light and porous with a subsoil of gravelly sand. Alluvial land is good. Sand, clay and peat are not satisfactory. Chalk is dangerous, on account of the possibility of pollution of water supplies through faults and fissures in the stratum.

Two methods of using land are in vogue—surface irrigation and filtration.

Surface Irrigation.—In principle this consists in dosing land with liquid in such amount as will not interfere with the growth of vegetation. The quantity of liquid applied per acre must vary with the strength of the liquid and the suitability of the soil. Only about one quarter of the area will be under irrigation at any one time, as part of the land will be resting after a period of dosing. Generally speaking, when the sewage is of an ordinary domestic type, one acre will suffice for 125–250 persons, if only the area actually under irrigation is referred to. This will be equivalent to 30–80 persons per acre of the total irrigable area. The land must be carefully under-drained at a depth usually of from 4–6 feet. Main drains are 6 inches in diameter and tributary drains 4 inches. The latter are made of ordinary agricultural porous pipes. The distance between the different branch drains will depend on the type of sub-soil. The liquid is led from the tanks in carriers, usually open concrete or stoneware channels, and distributed over the land in various ways. The ridge and furrow system is a common one. There, the liquid is run down the furrows, and crops, such as vegetables, are grown on the ridges. In the catch-water method, carriers are run along the face of a slope so that water overflowing from one passes over the intervening ground before it is picked up by the lower carrier. A disadvantage is that the higher ground gets more liquid, and more impure liquid, than the lower areas. In other farms liquid is allowed to run evenly over the surface of the irrigated area. The final effluent from the under-drains is collected at one or more points and run into some adjacent stream.

The action of land is to purify by mechanical filtration, to fix and retain in the soil various organic matters held in sewage, and to oxidise by the nitrifying organisms present. The process is largely a natural biological one. The number of organisms in sewage is considerably reduced by land treatment, and, although pathogenic organisms may conceivably succeed in passing, there is reason to believe that much of their virulence is lost. Sewage-sick land is land that has had so much sewage applied to it that no alkaline bases remain to combine with the acids formed by the nitrifying organisms. The addition of from 1–2 tons of lime per acre, combined with a period of rest, usually suffices to restore the purifying properties of the soil.

The best crops to grow on an irrigation farm are market-garden produce, rye-grass, lucerne, mangolds, peppermint, and perhaps fruit-trees. A certain amount of dairy farming is occasionally done, and frequently cattle are fattened in the summer months. No injury to health appears to result from working on sewage land, and vegetables from such farms, if not sewaged for some weeks prior to sale, may be eaten with impunity.

Land Filtration.—Here the earth is made to act in much the same way as a sand filter is used for water purification. The growing of crops, if practised at all, is a matter of secondary importance. The ground has usually to be specially prepared and very carefully under-drained. The surface soil is ploughed over periodically to break up the film of organic matter that always forms. One acre of such land will actually deal with the sewage of 750–1000 persons, but, if the total irrigable area is under consideration, the allowance should not exceed more than 250–500 persons per acre.

2. **Artificial Biological Methods**—

(*a*) **Percolating filters** consist usually of circular beds from 5–6 feet deep and up to 200 feet diameter, built of clinker, stone, coal, etc. The medium should not disintegrate through the action of the liquid, and should preferably be graded, the larger pieces (say 2½ inches diameter) being placed at the bottom and finer material (say ½ inch diameter) at the top. There may be a retaining circular wall of brickwork, but quite satisfactory results are obtained from placing larger lumps of clinker in the form of a loose surrounding wall. The floor of the bed contains drains for collecting the filtered liquid. Distribution of the tank liquor is performed usually by means of rotary arms driven by a constant head of water or by the intermittent discharge of a siphon. These filters are aerating beds. Oxygen is freely drawn into the interstices by the percolating fluid, and in time the pieces of clinker, etc., get coated with a slimy material full of organic matter. Bacteria are plentiful and worms of various sorts abound. It is usual to run these filters as continuously as possible, but it is often found advisable to give them a fortnight's rest every few months. If the tank liquor contains a fair amount of solids in suspension, the top layer of the filter may become clogged, and " ponding " of the surface may result. Rest is the best means of preventing such a condition. Algous growths occasionally form on the surface, and tend to interfere with the passage of the liquid through the filter. It is said that the application of a 20% solution of caustic soda will kill off such growths and keep the filter free for months to come, without injuring the purification process in any way. The rate of filtration must depend on the quality of the tank liquor and the fineness of the filtering medium, but as a rule not more than 200 gallons per cubic yard per day should be applied.

Occasionally these filters are made square, and distributors are arranged so that they move bodily over the surface of the medium. Fixed distributors are sometimes employed, but they invariably result in an uneven dosing of the bed. Such filters, if properly worked, cause no nuisance. Myriads of small flies of the genus Psychoda breed in the medium, but they do no harm, and are never found at any great distance from their breeding-place.

(*b*) **Contact beds** are really tanks filled with clinker, coke, broken stone, broken brick, saggars, etc. There is no advantage in grading the material. Such a bed is filled with tank liquor, allowed to stand full for a time, then emptied and left empty for several hours. The cycle usually followed is the eight-hour one—an hour to fill, two hours to stand full, one hour to empty and four hours to rest. The capacity of a new bed, with the medium in place, is about one-half that of the empty tank. As the bed matures the materials sink closer together and everything gets coated with a slime of organic matter, with the result that the capacity gets reduced to something like one-third that of the empty tank. As in the case of percolating filters, a good deal of animal life develops in the interstices of the filtering medium. Contact beds give good results under careful working. The process is, as before, an ærobic nitrifying one, due mainly to bacterial action. Air enters the bed in the intervals of rest that must always be given after each emptying. Both percolating filters and contact beds take some time to mature, and it is usually some weeks before nitrates appear to any extent in the final effluent. All the conditions favourable for nitrifying action—oxygen, moisture and warmth—are found in the interior of such beds.

The present trend of opinion is in favour of the construction of percolating filters rather than of contact beds, and unless the tank liquor under consideration is very dilute and free from suspended matter, it is advisable to pass it first through primary filters or contact beds, and then through a similar set of secondary ones. Although pathogenic organisms may survive artificial biological processes, it is unlikely that many of them retain their virulence after such an experience.

C. **Humus Tanks.**

The effluent from percolating filters and contact beds is apt to contain a good deal of fine, light organic matter called humus. It is necessary to allow this to settle before discharging the final effluent into a stream. This may be done by passing the filter effluent through small tanks—square tanks with a conical bottom answer well. In other cases small, fine sand filters are used. As a rule effluents from properly managed sewage farms contain very little suspended matter, hence humus tanks are unnecessary.

ACTIVATED SLUDGE SYSTEM

The two requirements of the system are: (1) means of thoroughly aerating sewage, and (2) a special sewage sludge. This method is of quite recent origin, and is unique in that purification is effected by tank treatment alone.

A special tank is necessary, with porous tile "diffusers" arranged in the bottom, through which compressed air can be forced either continuously or in gusts. The latter method appears to give the better results. The activated sludge is obtained by running screened sewage, free from detritus, into such a tank and holding it there with full aeration all the while, till nitrification is complete. This will probably take some weeks. A granular deposit forms and is allowed to settle. The supernatant liquid is run off, and more sewage is filled into the tank on the top of this sludge. Aeration is recommenced and continued till nitrification is again complete. The time required for this will be shorter than in the first instance. The process is repeated till the sludge occupies from 20–25% of the volume of the tank, when it should be possible to oxidise sewage by aeration in the presence of this activated sludge in the course of from four to eight hours. Should percolating filters already be in existence, the humus from these will form activated sludge if aerated by itself for a week or two. As this sludge grows in bulk it is possible to start the process off in other tanks by transferring to them a portion of the deposit from the original tank.

Once the system is in going order it may be worked either on the "fill and draw" principle or the method of continuous flow. The activated sludge is carried into intimate contact with every particle of sewage in the tank by means of the compressed air driven through the floor of the tank. Measures are adopted to prevent the sludge being carried over into the effluent channel. Fowler stated that there are three steps in the purification, firstly a clarifying, secondly a carbon oxidation, and thirdly nitrification. With an ordinary domestic sewage, in from four to eight hours a non-putrescible effluent may be got which will fall well within the Commission's limits for dissolved oxygen and suspended solids. Strong trade wastes, inimical to bacterial action, may adversely affect the process, but there is reason to believe that even these may be dealt with satisfactorily, if longer contact is given and special tanks are provided to equalise the sewage before treatment. The main advantages of the system are that nuisance is minimised, with the result that works may be placed near towns, the difficulty of dealing with sludge is greatly reduced, and, inasmuch as nitrogen is retained in the sludge, the manurial value is very considerable. It need hardly be pointed out that, after a certain time, the activated sludge will accumulate in the tanks to such an extent that a portion

of it will have to be removed. Plants have been installed, among other places, in Worcester, Stamford and Withington, and it has been shown that the system costs less in the first instance, and no more to maintain, than settlement tanks and filter beds. In addition, once a satisfactory method of placing the sludge on the market is devised, it is expected to find a ready sale as a fertiliser.

Refs.—*Journal Royal Sanitary Institute*, vol. xxxix., No. 1, 1918.
Journal Institute Sanitary Engineers, March and April 1916.

Sterilisation of Sewage.—Experiments have been carried out to determine what dose of disinfectant would be required to render tank liquors innocuous. A big reduction in the numbers of B. coli is what is principally looked for. Bleaching powder and Chloros (containing 10% available chlorine) are the chemicals most commonly advised, and in an ordinary sewage one or other would have to be added in the proportion of at least 10 to 15 parts of available chlorine per million parts of sewage before any marked effect on the numbers of B. coli would be observed. In addition, a contact of several hours would have to be given. The practice would add considerably to the cost of sewage purification, and has not been adopted in this country. It might be useful in the event of a considerable outbreak of epidemic disease such as enteric fever.

To recapitulate : Perhaps the most favoured type of sewage purification works in this country includes storm-water outflows and storm-water tanks, screens and detritus chambers, continuous-flow sedimentation tanks, percolating filters (primary and secondary) and humus tanks.

For an isolated country house—

(*a*) If the water supply is meagre, and no water-closets are in use, earth-closets with land irrigation of waste waters will prove satisfactory.

(*b*) If the water supply is ample, a cesspool system may be installed, in which the whole of the sewage, including the waste waters, but excluding rain-water, may be passed through the cesspool, and an overflow provided in some carefully selected area of ground. If an overflow is impossible, the cesspool must be made to take only the water-closet and slop-sink drainage, and the other waste waters must be treated on land. Small septic tank and filter-bed installations may be obtained for very big country houses, but these require careful attention.

Disposal of Dry Refuse.—Dry refuse should be kept by the householder in a galvanised-iron covered bin and collected daily by the dust collector. Fixed ashpits are unsatisfactory, and any that exist should be emptied at least once a week.

Stable manure in towns should be removed at least two or three times a week, and disposed of to farmers or other interested persons. It is advisable to remove refuse during the early hours of the morning.

There are three methods of disposal—

1. **On Land.**—For levelling waste land or filling up old quarries, etc. Refuse dumps are always a source of nuisance, on account of the papers and dust that are blown about, and on account of their affording breeding-places for flies, rats and other vermin. Water supplies may also be contaminated.

2. **In the Sea.**—Unless carried a considerable distance out to sea much of the rubbish will be washed back on the shore.

3. **Burning.**—This is the only really satisfactory method of getting rid of dry refuse.

Refuse destructors may be either "low temperature" or "high temperature." The latter is the more modern method. Each destructor consists of a series of cells or furnaces placed either in a row or back to back. These cells must be lined with very fire-resisting material to withstand the great heat generated. The rubbish carts tip the refuse on an elevated platform above the cells, and it is shot down into the cells either by hand or by a special hopper arrangement. At first the refuse falls on a drying-hearth, and is thus rendered more readily combustible. The flue is led off from the front of the cell, so that all the gases have to pass over the glowing portion of the fire before escaping. This minimises risk of nuisance from smell. Arrangements exist also for removing dust from the flue. The furnaces are clinkered by hand from the front. A forced draught is, of course, always employed. With a destructor of this type from 10–20 tons of refuse can be burned per cell per day. One cell suffices for about 10,000 inhabitants. A well-managed and well-constructed destructor should be no nuisance in the neighbourhood, hence it is not necessary to select a site far removed from all buildings. The site must be accessible, otherwise much time and money will be spent in cartage. The heat generated may be made to produce steam for electricity works, disinfecting stations, laundries, etc., but it must be remembered that the first duty of the destructor is to destroy rubbish, a fact that is sometimes lost sight of when other work is carried on in the same premises. The clinker produced, if the refuse has been picked over beforehand, may be used for making roads, concrete blocks, medium for filter beds, etc., and if of high grade commands a ready sale.

SECTION III

AIR, VENTILATION, HEATING AND LIGHTING

Air.—Composition of external air, by volume.

N 78·07%
O 20·95%
CO_2 0·03–0·04%

In addition, air contains nearly 1% of Argon and traces of H, NH_3, Neon, Krypton, etc. Aqueous vapour averaging about 1% is present also. The amount of oxygen varies but slightly under normal conditions. The air of mines, however, sometimes contains as little as 18%. Combustion is not supported with a percentage lower than about 17. An individual at rest feels no ill effects till the oxygen is reduced to 11% or 12%, and consciousness is retained till the figure reaches 7%. The CO_2 content varies considerably, as much as 0·3 or 0·4% being not infrequently present in the air of ill-ventilated rooms. It is only when the amount reaches 5–10% that untoward symptoms are produced in human beings. Nitrogen is an inert gas and need not be considered.

VITIATION OF THE ATMOSPHERE

1. Impurities of respiration.
2. Impurities of combustion.
3. Impurities due to various trade processes.

1. **Respiration.**—Each respiration of an adult amounts to about 500 c.c. The expired air has lost about 4% O and gained about 4% CO_2. In addition, its temperature is raised to nearly 37° C., and it is almost saturated with water vapour. Micro-organisms in varying numbers are also given off on forced expiration. Body emanations may be included under this heading. The principal of these is sweat, which averages about 1000 c.c. per twenty-four hours.

Micro-organisms are few in number in pure air from such situations as mid-ocean or mountain tops. In inhabited rooms as many as 300,000 to 500,000 per cubic metre (1000 litres) may be found. In the open air a shower of rain tends to carry down many bacteria, and thus purifies the air to a certain extent.

Gordon has shown that a study of the cocci present in the atmosphere of rooms is sometimes of value. He differentiated three types: (*a*) streptococcus salivarius, found constantly in the saliva and indicative of contamination of air by loud talking or coughing, (*b*) staphylococcus epidermidis albus, derived from the skin, and (*c*) streptococcus equinus, present in horse manure and probably carried into rooms in dust on boots. A search for these micro-organisms affords means of estimating the purity of an atmosphere, and gives an indication of how far pathogenic bacteria expelled from the respiratory passages of infected persons are likely to cause risk of spread of disease. It must be remembered that during loud talking organisms may be sprayed to a distance of over 20 feet from the speaker, while coughing serves to carry them still further. Organisms given off from infected persons are liable to retain their vitality for varying periods of time in the dust and furnishings of rooms and may thus continue to propagate disease. Conditions affecting the respiratory passages are obviously those most likely to be spread in this way.

2. **Combustion.**—Most atmospheric pollution in large towns is due to the products of combustion. The ordinary domestic fireplace is a great offender, while in the large manufacturing centres in the North and Midlands, factory furnaces are responsible for the bulk of contamination.

Coal, when burned, produces CO, CO_2; sulphur compounds such as CS_2, SO_2, and H_2S; ammonium compounds and water vapour. One pound of coal requires about 300 cubic feet of air for its complete combustion. The oxides of carbon are dangerous only in escapes of flue gases. The sulphur compounds are irritating to mucous membranes (especially in times of fog), and are harmful in bronchitis, asthma, and respiratory diseases generally. They also affect vegetation and building stones.

Coal gas is made by the destructive distillation of coal in iron retorts. The resulting products are passed through a condenser where coal tar and ammoniacal liquor are separated. The gas is finally purified by passage over slaked lime or oxyhydrate of iron to remove sulphur compounds. The gas now consists of: (*a*) Illuminants containing carbon which becomes incandescent when heated, *e.g.* ethylene, acetylene, benzol. (*b*) Non-illuminants, *e.g.* H, CH_4, CO, CO_2, and N, with traces of S compounds.

The average composition of coal gas—

H	46%
CH_4	37%
CO	7%
Illuminants	5%
N, Sulphurous acid, etc.	5%

Products of combustion—

N 60%
CO_2 7%
CO 5–6%
Water 16%

Traces of SO_2, NH_3, etc.

London gas must not contain H_2S, and the total amount of S is also limited (17 grains per 100 cubic feet). One cubic foot of gas on combustion combines with the O in 7 cubic feet of air, and half a cubic foot of CO_2 and over 1 cubic foot of water vapour are produced. The temperature of 30,000 cubic feet of air is thereby raised 1° F. A common gas burner consumes about 4 cubic feet of gas per hour and gives off about 2 cubic feet of CO_2.

Water Gas or Producer Gas is made by passing steam through incandescent coke, with the formation mainly of CO and H. The amount of CO may be as much as 50%. Water gas is odourless, and dangerous on account of the high percentage of CO. It is useful mainly for heating purposes. This gas may be "carburetted" by passage over heated oils containing much hydrocarbon. Carburetted gas (about 30% CO) has much the same smell as ordinary coal gas, and is cheaper to produce. The two are frequently mixed.

Acetylene (C_2H_2) is formed by the action of water on calcium carbide. It is used extensively, especially in the lighting of country houses. Mixtures of it with air in the proportion of 1 in 12 are explosive and the continued inhalation of small quantities such as would escape from defective pipes is dangerous to health.

Smoke Nuisance.—In districts where much of the smoke issues from factory chimneys much can be done to abate the nuisance. In London, however, where domestic fireplaces are the principal offenders, it is probable that only the substitution of gas fires, electric radiators or central heating would produce any marked degree of improvement.

Among devices used in factory furnaces for preventing smoke-nuisances are—

1. Skilled stoking by hand.
2. Mechanical stokers, either of the sprinkler or the coking variety. The smoke produced by the addition of fresh coal should be made to pass over an incandescent portion of the fire.
3. Forced draughts admitted either in front of the furnace or through a split-bridge at the rear.
4. The use of anthracite-coal or coke.

Certain legal powers are given under the Public Health Act, 1875 (p. 264), which enable local authorities to deal with the discharge of smoke from any factory furnace which does not, so far as practicable, consume its own smoke. "Black" smoke

also may not be discharged in such quantity as to be a nuisance. The practice in most places is to allow so many minutes escape of black smoke per boiler per hour—anything above that is considered to be an offence under the Act. Thus in Sheffield two minutes "black" smoke per hour is allowed for one boiler, three minutes for two boilers, four minutes for three boilers, six minutes for four or more boilers. Some allowance must also be made for the issue of smoke at the time of lighting up the furnace. Much discussion has taken place in courts of law as to what exactly constitutes "black" smoke.

A smoke-polluted atmosphere is certainly injurious to health. Sunlight is diminished and respiratory disease encouraged. It has even been suggested that such pollution is accountable for a good deal of infantile mortality.

3. **Trade Impurities.**—These include dust and injurious gases and are dealt with in the section on Industrial Diseases (p. 201).

VENTILATION

Two preliminary data are necessary in dealing with the ventilation of occupied rooms: 1. The delivery of fresh air in cubic feet per head per hour. 2. The amount of cubic space per individual.

1. An indication of the impurity of the air of occupied rooms may be got from the estimation of the amount of CO_2 present. In a mixed assembly at rest the CO_2 exhaled is reckoned at 0·6 cubic foot per head per hour. From a large series of observations de Chaumont decided that, when the CO_2 in the air of a room exceeded by more than 0·02% the percentage in the outside air, a sensation of stuffiness became apparent to the senses. He therefore fixed as the "allowable respiratory impurity" 0·02% CO_2. On this principle de Chaumont devised a formula which enables us theoretically to calculate the amount of fresh air that should be delivered per hour to an occupied room.

$$D = \frac{e}{r}$$

D = delivery of fresh air in cubic feet per hour.

e = actual amount of CO_2 exhaled per hour in cubic feet (0·6 cubic foot taken as an average).

r = allowable respiratory impurity in terms of cubic feet of CO_2 (*i. e.* 0·02 cubic foot per 100 cubic feet or 0·0002 in 1 cubic foot).

Thus $$D = \frac{0{\cdot}6}{0{\cdot}0002} = 3000$$

This means that on an average an individual should receive 3000 cubic feet of fresh air per hour if satisfactory ventilation

is to be maintained, and this is the standard that is adopted generally in natural ventilation.

While the "allowable respiratory impurity" as laid down by de Chaumont is of excellent theoretical value as applied in the above formula, many observers have found that, practically, considerably larger percentages of CO_2 may be present in an atmosphere without any apparent insufficiency of ventilation. It must be understood that CO_2 is not to be regarded as the cause of the ill effects produced in close atmospheres, it is merely an index of the sufficiency of the ventilating arrangements. Thus in humid rooms of cotton factories a limit of 0·09% CO_2 is fixed, and various other standards varying from 0·1–0·12% have been suggested for rooms liable to overcrowding. Artificial lighting, other than electric, will, of course, increase the percentage of CO_2.

2. The amount of cubic space per individual is equally important. The ideal standard for dwelling-rooms is 1000 cubic feet per occupant. This allows of the air being renewed three times in the course of an hour. More frequent renewal in this country would be apt to cause a feeling of draught, were the incoming air not warmed. A current of air at 60° F. entering a room at a velocity of 3 feet per second is definitely perceptible, at a greater velocity a sensation of draught is experienced. Square feet of floor space per occupant should always be stated as well as cubic feet, for height of a room will not compensate for lessened floor space. Thus 1000 cubic feet of space is obtained by a measurement of $10 \times 10 \times 10$, but it might equally well be obtained by $5 \times 5 \times 40$. In the latter case the floor space would only be 25 square feet as compared with 100 in the former, and the height of the room would be 40 feet as compared with 10. It is obvious that air will tend to stagnate in the upper zones of a very high room. Hence it is customary in calculating cubic space to neglect any height over 12–13 feet. (Parkes and Kenwood give the table on next page.)

In fever hospitals a cubic space of 2000 feet is usually aimed at, with a floor measurement per bed of 144 square feet.

"**Stuffiness.**"—In a report to the Local Government Board (New Series, No. 100, 1914) Professor Leonard Hill discusses the various theories put forward to account for stuffiness, and offers a new explanation of his own. Three suppositions formally prevailed regarding the causation of unpleasant sensations experienced in ill-ventilated rooms.

1. That the air becomes impoverished of oxygen.
2. That it contains excess of CO_2.
3. That it contains an organic poison from the expired air.

As regards the oxygen theory, Professor Hill conducted certain experiments in a hermetically sealed chamber in which the composition of the air could be absolutely controlled. In this he enclosed several students, and found that they remained

	Minimum space per head in cubic feet.	Authority.
Common lodging - houses (sleeping-rooms).	300	Local Government Board (Model Bye-laws).
Registered lodging-houses—		
Rooms occupied by day and night.	400	" "
Rooms occupied by night only.	300	" "
Non-textile workrooms.	250	Factory Act, 1901.
Non - textile workrooms during overtime.	400	" " "
Underground bakehouses.	500	Order under Factory Act, 1901.
Above-ground bakehouses where night work is carried on by artificial light other than electric light.	400 cu. ft. between 9 p.m. and 6 a.m.	
Army barracks.	600	British Army Regulations.
Army hospital wards.	1200	" " "
Public Elementary Schools.	80 (min. floor space, 8 sq. ft.)	Education Department.
London County Council Schools.	130 (min. floor space, 10 sq. ft.)	London County Council.
Canal boats (persons under 12 years).	40	Local Government Board. Regulations under the Canal Boats Act, 1877.
Canal boats (persons over 12 years).	60	
Seamens' cabins.	120	Merchant Shipping Act, 1906.
Cows in cowsheds.	800	Local Government Board Model Regulations under the Dairies, Cowsheds and Milk-shops Order.

quite comfortable when the percentage of O was lowered below 17 (when a match could not burn). A diminution of more than 1% is practically never noted in occupied rooms, whereas at heights of 5000 feet and over, where people live and thrive, the oxygen content of the air is much lower. "So long as there is a partial pressure of O sufficient to change most of the hæmoglobin of the venous blood into oxyhæmoglobin during its passage through the lungs, there can arise no lack of oxygen." "A person not exerting himself will fail to observe any effect until the oxygen has been reduced to 12 or 10%, and consciousness will not be lost until the percentage sinks below 7."

The CO_2 in an atmosphere never increases to any great extent. About 0·04% is normally present in outside air, while in overcrowded places like theatres and lecture-halls the figure may be 0·3 or 0·35%. It is only when concentrations of 3 or 4% are

breathed that respirations become noticeably increased. In submarines men could work in atmospheres containing as much as 3·5%, and in the fermentation rooms of breweries amounts varying from 1·5–2·5% have been detected.

With regard to the organic poison theory, Professor Hill and Flack kept animals alive and healthy in the bottom of deep boxes so arranged that at least 1% CO_2 was present at all times, and consequently a great deal of breath exhalation as well. No evil results followed.

Professor Hill points out that, while evidence in favour of the chemical view is lacking, there is convincing proof that heat stagnation, due to excess of moisture and lack of air movement, is the cause of the discomfort. In the experimental chamber already mentioned, students were exposed to a wet-bulb temperature of 82–85° F. (the dry-bulb reading being a degree or two higher), a percentage of O less than 17 and a CO_2 percentage of from 3–4. While the air was still, considerable discomfort was experienced, but great relief was obtained when electric fans in the roof were set in motion. "The same stale air, containing 3–4% CO_2 and 16–17% O, was whirled, but the movement of the air gave great relief because the air was 80–85° F. (wet-bulb), while the air enmeshed in their clothes in contact with their skin was 98–99° F. (wet-bulb). The whirling away of this stationary air cooled the body effectually, for air can hold considerably more water vapour at 98–99° F. than at 80–85° F. The symptoms arising in the so-called vitiated atmosphere of crowded rooms are dependent on heat stagnation. The essential thing is to keep down the saturation of the air in contact with the skin. The air entangled in the clothes becomes warmed up to body temperature and saturated with moisture if there is no wind to drive it away."

An instrument is necessary which will indicate not average temperature, but rate of cooling or heat loss. Professor Hill's kata-thermometer does this. It is a large-bulb spirit thermometer graduated from 110°–90° F., with distinctive marks on the stem at 110°, 100°, and 90°. Two such instruments are generally employed—one with the bulb uncovered, the dry kata, and the other covered with a fine cotton mesh, the wet kata. The bulbs are immersed in water at about 150° F. until the spirit rises into the small bulb at the top of the stem. The excess of water is then jerked off the wet bulb, and the other dried. The instruments are suspended in air, and the rates of cooling from 110°–100° and from 100°–90° are taken with a stop watch. The wet kata loses heat by evaporation, the dry kata by radiation and convection. The instruments are graduated by taking many observations under a great variety of conditions, both indoor and outdoor. On an ideal summer day the outdoor reading (110°–100°) was twenty-five seconds for the wet-bulb

and eighty-five seconds for the dry-bulb kata. Indoors at the seaside on an ideal summer day the readings were fifty seconds and 140 seconds respectively.

It may thus be concluded that the three main factors that unite to produce a pleasant and healthful atmosphere are a relative humidity not exceeding 75%, a temperature about 60° F., and continual gentle movement of the air.

Methods of ventilation may be divided into Natural and Artificial.

NATURAL VENTILATION is dependent on three of the forces of Nature—

(*a*) **Diffusion.**—Graham's Law states that the force of diffusion of gases varies inversely as the square roots of their densities. Thus oxygen with a density of 16 diffuses with only one-fourth of the force of hydrogen with a density of 1. As most materials used for house construction are more or less porous, a slight amount of interchange of indoor and outdoor air takes place in this way.

(*b*) **Winds** may act either by perflation, as when the doors and windows of a room are thrown open, or by aspiration, as when wind blowing over the top of a chimney exercises an upward suction effect on the air in the flue. Winds are, however, irregular in action. There may be no wind at all, or else a wind of such force that it is difficult to control.

(*c*) **The Movement of Masses of Air of Unequal Temperature.**—Hot air is lighter than cold air, and, as it rises, it is replaced by a current of colder, heavier air. This is the chief force at work in natural ventilation. By Montgolfier's formula it is possible to calculate theoretically the velocity of air entering through any orifice, provided we know the difference in temperature between the outside and the inside air and the height of the exit ventilation opening above the inlet (see p. 340). The greater the difference of temperature, the greater will be the velocity of the incoming air. On this principle depends the ventilating power of our ordinary coal fires.

Natural ventilation may be aided by various arrangements in cities, houses, etc. Thus "external ventilation" means the provision of open spaces, wide streets and suitable back-yards in towns. The model bye-laws relating to new streets require that all carriage ways shall be at least 36 feet wide and all roads not to be used as carriage ways at least 24 feet wide and open at one end. At least 150 square feet of yard space must be provided at the back of, and must belong to, each building (see p. 290). Back-to-back houses (unless approved by the M.O.H.) are prohibited under the Housing and Town Planning Act, 1909. These provisions for external ventilation allow of a free circulation of air around individual dwelling-houses.

Natural Ventilation of Rooms.—Doors, windows and chimneys

are the usual openings provided, not necessarily primarily for ventilation purposes. Special openings are of two kinds—fresh-air inlets and foul-air outlets. **Inlets** are best placed at a height of about 5 feet from the floor, and some arrangement should be provided for deflecting the air upwards as it enters. Otherwise, instead of mingling with the warmed air of the room, the cold incoming air will simply flow down the wall and along the floor to the nearest outlet—usually the chimney flue. For the same reason inlets should not be too near outlets. In this country about 24 square inches of inlet are necessary for each person. A common practice is to break up the air into a number of fine streams, *e. g.* by means of grids, as a sensation of draught is less likely to be produced. Unless incoming air is warmed the entering velocity should not exceed 3 feet per second. Fresh air should always be admitted direct from outside, never from passages, and, if necessary, it may be filtered through cotton-wool or canvas screens or made to impinge on a plate of water, in order to remove any dirt it may carry in suspension. All air ducts should be as short and as straight as possible, and should be accessible in every part for cleansing. **Outlets** should be near the ceiling, all should be at the same level, and extraction ducts should be as nearly as possible of the same length. The foul air is warmer than the outside air, and will therefore rise through any opening provided for it near the ceiling. It is advisable to maintain the temperature of this outgoing air, and this is sometimes done by enclosing the extract duct in the wall by the side of the flue. What has been said regarding inlet ducts applies equally well to outlet. Not infrequently outlets act as inlets and vice versa, depending on the force of the wind, bad construction, or cooling of the outgoing foul air.

Friction in ducts varies directly with the length and, in the case of circular ducts, inversely with the diameter. In ducts other than circular it varies inversely with the square roots of the sectional areas. It also increases with the square of the velocity. A circular duct offers the least resistance. One right-angle bend reduces the velocity by one-half, two reduce it to one-fourth. If bends cannot be avoided they should be rounded off as much as possible. A rough surface also increases friction. The velocity of air passing through a duct may be estimated by means of a small anemometer or current meter. This instrument records, so to speak, the distance travelled by the air within a fixed period of time. It should be placed at a point two-fifths of the diameter distant from the periphery of the duct, the catch should be unloosed, and by means of a stop-watch a reading taken at the end of one minute or more. Friction is allowed for by the addition of a factor to the result.

Once the velocity in feet per second of the entering air has been estimated, the actual amount delivered may be obtained

by the formula $Q = VS$ where $Q =$ the volume admitted in cubic feet per second, $V =$ the velocity in feet per second and $S =$ the sectional area of the duct in square feet.

PRACTICAL APPLIANCES IN NATURAL VENTILATION

A. **Window Openings.**

1. Hinckes-Bird's window.
2. Holes pierced in the lower transverse member of the top sash of a window.
3. One pane falling inwards as a hopper inlet with side checks.
4. Louvred panes.
5. Horizontal slits cut in one of the panes.
6. Cooper's disc.

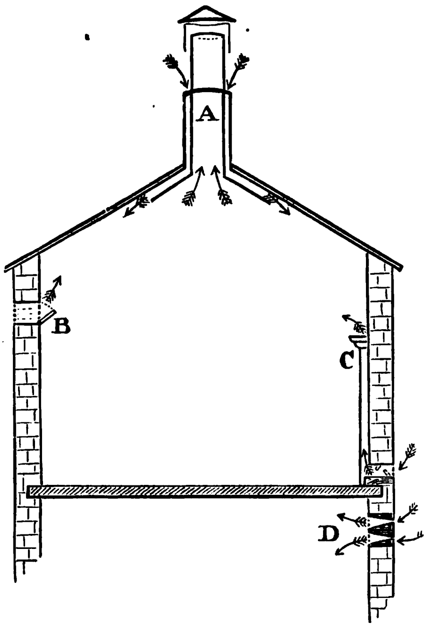

Fig. 15.—Ventilating openings.
A, McKinnell's ventilator; B, Sherringham valve; C, Tobin's tube with water-trap; D, Ellison's conical brick ventilators.

B. **Wall Openings.**

1. Ellison's bricks—openings ¼ inch outside and 4½ inches inside.
2. Sherringham's valve—9 inches × 3 inches. Several are better than one. Avoid placing opposite one another.
3. Tobin's tube—5–6 feet high.
4. Neil Arnott's valve. This almost comes under the heading of artificial ventilation. It consists of a mica-flap valve leading into the chimney flue. When the pressure in the room is greater than in the flue the valve opens and allows foul air to escape.

C. **Roof Openings**—*e. g.* the cowls ordinarily fixed on the roofs of railway carriages. Through these openings the foul air is aspirated when the train is in motion.

Chimney cowls are frequently useless, especially those that are made to revolve. All that is necessary is a metal plate fixed horizontally a few inches above the mouth of the chimney in order to deflect any downward gusts of wind caused by adjoining walls and roofs. Either the "fixed downcast" or "fixed upcast" type is satisfactory.

Sylvester's System was an old-fashioned method whereby fresh

air was collected by means of a cowl, placed at a small height above the ground, and made to face the direction of the wind. The air so collected was led to the basement of the house, and, after being warmed, was passed through ducts to the various rooms.

Arrangements for Warming Incoming Air.—Air may be warmed to about 58° F. in order to diminish the sensation of draught. The temperature of incoming air should be about 4° F. less than that of the room itself. Such air is at times used as the sole means of warming as well as of ventilating a room. This procedure is unwise, as overheating of the incoming air is apt to be practised.

(*a*) Air may be passed through chambers containing low-pressure hot-water pipes, or a radiator may be placed opposite an air inlet (ventilating radiator). These are good methods.

(*b*) Ventilating fireplaces warm incoming cold air in a fire-brick chamber at the back of the actual fireplace. The warmed air is then discharged into the room at or above the level of the mantelshelf. Galton's grate is the best-known example.

(*c*) Ventilating stoves, such as Bond's euthermic and George's calorigen. These are not good, as the air is heated by contact with hot cast-iron surfaces. The air becomes unduly dry, and is apt to produce "relaxed throat," headache, and other symptoms in the occupants of rooms so heated.

Both (*b*) and (*c*) may be considered as means of heating as well as ventilating.

ARTIFICIAL VENTILATION—where air is set in motion by means of some mechanical device.

1. Extraction methods. 2. Propulsion methods. 3. A combination of the two.

1. **Extraction of Air.**

(*a*) **Heat.**—This is well illustrated in the case of the ordinary fireplace. Air passes up the flue at from 3–6 feet per second, and the result is an hourly discharge of some 10,000–18,000 cubic feet. (Even when a fire is not burning the flue is perhaps the main outlet in the room. In the model byelaws relating to buildings, it is specified that in rooms not supplied with a fireplace and flue, a special ventilating opening of not less than 100 square inches must be provided.)

In extraction shafts heat is frequently applied in the form of hot water or steam pipes or gas jets. The combustion of 1 cubic foot of gas causes the discharge of 1000 cubic feet of air. Mines were formerly ventilated by means of a furnace at the bottom of an "upcast" shaft, fresh air being sucked in through a "downcast" shaft at another point. Roof ventilators fixed above gas chandeliers in large halls or theatres are another instance of extraction by heat. In McKinnel's ventilator not only is foul air removed by these means, but the incoming air is warmed by contact with the outlet shaft.

(*b*) **Extraction by Steam Jets.**—One volume of steam will set in motion 217 times its own bulk of air. The method is sometimes applied to factories.

(*c*) **Extraction by Fans.**—This is much the commonest method, and is used extensively in factories, etc., where dusty and dangerous trades are being carried on. Care must be taken to place the mouths of the extraction shafts at such points that the dust and fumes will be sucked out of the work-room by the most direct route, *e. g.* downward suction from work benches or hoods over grindstones. Galvanised iron forms the best material for the ducts.

The main disadvantage of extraction methods of ventilation is the difficulty of controlling the source of incoming air. Air will enter the room from adjacent corridors, water-closets and other undesirable places unless special inlet openings are very carefully provided. In addition, if a furnace is relied on as the extraction force it is likely to be very irregular in action. Rooms near an extraction fan are apt to be acted on much more vigorously than those at a distance. This may be obviated by increasing the size of the ducts leading from the distant rooms or bending on themselves the ducts from the nearer rooms.

2. **Propulsion of Air, or the Plenum System.**—In this system air is collected at a fixed point and driven through ducts by fans to the various rooms. Definite outlets are arranged for the escape of foul air, hence windows and doors must be kept closed. The best arrangement is for the inlets to be placed fairly high up in the rooms with the outlets on the same side, but lower down. This causes a thorough circulation of the air. It is stated that the velocity of the entering air should not exceed 5 feet per second in the main ducts, or 1½–2 feet in the smaller ducts where they enter the rooms. The air may be filtered through special screens, moistened if necessary by a stream of water, and heated by a battery of hot pipes.

The advantages of the Plenum system are—

(*a*) The source of the air can be selected.

(*b*) The amount of air delivered can be regulated exactly.

(*c*) The air can be treated in any way desired.

(*d*) A more frequent renewal of air is possible in this way than under natural conditions.

For buildings occupied temporarily by large numbers of people the Plenum system offers considerable advantages.

Disadvantages—

(*a*) Air so treated becomes devitalised. It loses its freshness and does not produce the same healthful conditions as ordinary fresh air.

(*b*) Closed windows are a bad object lesson, especially in schools.

3. **The Balance System** is a combined propulsion and extraction system. Warmed pure air is admitted on opposite sides of the

room or hall at a height of about 7 feet from the floor, and foul air is extracted from openings in the ceiling. Fans supply the motive force in both cases, and the secret of success lies in the careful regulation of these fans so that an exact balance is maintained. Prior to occupation the hall should be warmed by radiators. All windows should be double to prevent loss of heat by radiation or the formation of disturbing air currents due to cooling. This is the most satisfactory artificial system for general purposes.

It is difficult to apply any system of mechanical ventilation to an old building.

Comparison of Natural and Artificial Methods.—Unless provision is made to exclude all entering air natural ventilation is always proceeding, and before steps are taken to employ artificial methods it should be ascertained whether full use has been made of all natural means.. Under certain conditions of overcrowding natural methods may have to be supplemented by artificial. It has been found, for example, that schoolrooms and hospitals can be ventilated satisfactorily by a careful arrangement of windows, while public halls, theatres, cinema-houses and the like frequently require either artificial aids to ventilation or even a complete mechanical system. In factories where dust and gases must be rapidly removed, some method of extraction must be employed. In the ordinary dwelling-house, provided open windows are not an object of dread to the occupants, the only artificial arrangement needed is the extractive force supplied by the fireplace and flue.

Ozonisation of Air.—Ozone is produced artificially by the action of a silent electric discharge on atmospheric air. Air containing from 1–5 parts of O_3 per million is sometimes used in ventilation. The mixture has a characteristic smell and, if more than 10 parts of O_3 per million are present, it becomes too irritating to breathe. It is estimated that at least 0·3% of ozone would be required to kill B. typhosus in one hour, hence the disinfectant properties of the mixture used in ventilation work must be exceedingly small. It is of some value, however, as a deodoriser.

HOW TO EXAMINE THE SUFFICIENCY OF VENTILATION IN AN OCCUPIED ROOM

1. Make the visit at the time of maximum contamination—in a sleeping apartment just before the occupants rise in the morning.

2. Enter rapidly, and at once note the "sense-impression"—*i. e.* whether the air is stuffy, smelly or otherwise oppressive. This gives to an experienced observer as good an indication of the state of the atmosphere as any other test.

3. Count the number of occupants, gas-burners alight, open windows and other fresh air inlets. Note any fires burning. The actual amount of air entering can be calculated with the aid of a small current meter.

4. Measure up the room.

5. Take wet- and dry-bulb thermometer readings and, if so desired, wet and dry kata-thermometer readings as well.

6. Estimate the percentage of CO_2 in the air. Haldane's portable apparatus gives sufficiently accurate results after some practice, and is much less cumbersome than Pettenkofer's method. It will be found that percentages over 0·1 will, in the huge majority of cases, accompany a "sense-impression" of stuffiness, closed windows, overcrowding and general insufficiency of ventilation.

7. A bacteriological examination of the air may be made, but the technique is rather involved if useful results are to be obtained. Exposure of plates containing media gives little information of value.

HEATING

The main methods of warming in this country are open fires, stoves, hot air, hot water or steam, and electricity.

For general comfort a temperature of 60°–65° F. should be maintained.

The physical phenomena of radiation, convection, and conduction are all involved in any system of heating. Open fires warm chiefly by radiation. Their initial outlay is small, but their upkeep is costly. In addition to this they are dirty and wasteful, as much of the heat generated is lost by its passage up the chimney. The heat that does radiate into the room is unequally distributed, in accordance with the law that the amount of heat received by a body is inversely proportional to the square of its distance from the source of heat. Iron was largely employed in the construction of the older form of grate. This again constitutes another great loss of heat. The heat absorbed by the iron, although some is imparted to the surrounding air, escapes mostly unutilised up the chimney-flue. In order to insulate the heat the modern grate is lined with fire-brick, and the amount of iron reduced to a minimum. For the same purpose Pridgen Teale made the following suggestions. The throat of the chimney should be contracted, the back of the fireplace should slope towards the room, the bottom should be deep from front to back and contain narrow slits, the bars in front should be narrow and preferably vertical, and the space beneath should be closed in front by a shield to act as an "economiser." Fires, on the other hand, are very cheerful, and provide an excellent means of ventilation. The late Sir Douglas Galton advocated the use of a ventilating grate, whereby

the waste heat of the fire is used to warm incoming air. A chamber nearly surrounds the grate, but is in no way connected with it. By means of a pipe the external air is conducted to the room, passing through the chamber en route. In that way the air is warmed. The inlet terminates in the room at a level between the ceiling and the fireplace.

Gas fires, which are simply bunsen-burners playing on asbestos or hollow balls of firebrick, have the advantage of being more cleanly, as they produce no smoke or ashes. They are also convenient, as they can be lighted and extinguished at a moment's notice, and the amount of heat can be regulated to meet the requirements demanded. They are, however, costly, they do not ventilate as efficiently as open fires, they dry the air, and are a danger, inasmuch as unburnt gas, carbon monoxide, and carbonic acid may gain access to the room. The dryness of the air may be lessened by exposing trays containing water. Even with this expedient it is doubtful whether enough water evaporates to keep the air in a sufficiently moist condition. On the whole, however, they must be regarded as satisfactory. A flue is essential. They warm chiefly by radiation.

Stoves in which anthracite coal is burnt are now being largely employed. Their chief advantages are, they require little attention, and practically no smoke is generated. On the other hand, they evolve large quantities of carbon monoxide. It is of paramount importance that all stoves should be constructed in such a way that no product of combustion can escape except by the shaft provided for that special purpose. They should be made of wrought iron, or, if cast iron is used, they should be lined with fire-brick. It has been alleged that the carbon present in cast iron is apt to be partially oxidised, resulting in the formation of more carbon monoxide. The firebrick is a protection against this, and, in addition, prevents the stoves getting red hot. They warm mainly by radiation.

There are also many forms of ventilating stoves. A common pattern is known as George's "Calorigen stove." A coil of pipe, one end communicating with the outside air and the other with the room, passes through a stove or chamber in which gas is burnt. As a rule the incoming air is rendered too hot and too dry. With Bond's "Euthermic stove" the tube conveying the air is greatly expanded within the stove. In that way the volume of air to be heated is so increased that the liability of its being over-dried and over-heated is very considerably reduced. In both cases provision should be made for the escape of the burnt gas to the external air.

Whatever stove is used an unpleasant smell is apt to result. This is attributed to the burning of the organic matter in the air by contact with the hot iron.

Hot air has been employed for warming buildings, and is

applicable more particularly to large ones. The fresh air is usually warmed in a special chamber in the basement, and then, by means of fans, driven through conduits to all parts of the building. The air may also be moistened, filtered or washed. It is not advisable as a rule to depend upon the same hot air for both warming and ventilating.

As regards hot water as a means of heating, the fact that water becomes lighter when its temperature is raised enables a circulation to be maintained through any set of closed pipes. Two systems are in common use—the low pressure, where the water has a temperature never in excess of 212° F., and the high pressure known as Perkin's system, in which a temperature of 300° F. is often reached. With the former, a boiler is placed in the basement of the building. The hot water leaves the top of the boiler by a pipe which traverses the various rooms of the building, or it may be made to serve radiators to increase the heating surface. The circuit is completed by the pipe re-entering the boiler at the bottom. Provision must be made at the top of the system to allow for the expansion of the water. The size of the pipe is usually 4 inches, 12 feet being required to warm 1000 cubic feet of air space.

With the high-pressure system strong iron pipes seven-eighths of an inch in diameter are required. These pipes are hermetically sealed, but, to allow for expansion, a weight valve is placed at the highest part, or an "expansion chamber" is provided. About one-sixth of the total length of the pipe is coiled up within a furnace. Heat is thus applied, and, as the water in consequence is subjected to an increased pressure, the temperature exceeds 212° F. No boiler is employed, and as a rule radiators are not necessary, the pipe itself being sufficient. To keep 1000 cubic feet of air at a temperature of about 60° F., 8 feet of pipe will suffice. It is inadvisable to apply this method to a school, as the pipes get so hot that the children are apt to burn themselves. Again a "stuffy" smell often accompanies its employment, due in all probability, as has been said, to the effect which the hot iron has on particulate organic matter contained in the air.

Where steam is available, as in the case of factories, it is sometimes utilised as a means of warming. The same principle is involved as with the low-pressure hot-water system. Steam is made to permeate pipes and radiators. In the act of condensing, the steam gives up its latent heat, and the water resulting flows by gravitation back to the boiler. The success of this method depends very largely upon the means provided for the return of the condensed water. For this purpose a special set of pipes of ample diameter is usually employed. Where large buildings are concerned the steam is condensed before the circulation is complete. This is due partly to an

insufficient steam pressure, and partly to the coldness of the pipes. In order to obviate this, the passage of the steam is assisted by a suction pump placed at the end of the system, *i. e.* just before the water re-enters the boiler; when the pipes and radiators have reached such a temperature that the condensation of the steam is retarded, the suction process is discontinued. Hot water and steam methods warm mainly by convection and to some extent by radiation.

"Ventilating radiators" are now in fairly common use. They are fixed against an external wall in front of a fresh-air opening placed near the floor. The incoming air, warmed in that way, may be given an upward direction by means of a baffle-plate vertically attached to the front of the radiator.

Electric radiators have many hygienic advantages. They are very clean, easy to regulate, and no products of combustion are formed. On the other hand, they are expensive, and this tells against their general use. They warm by radiation and convection.

LIGHTING

The common forms of artificial lighting include electricity, gas, oil-lamps, and candles. The standard by which all lighting is measured is one sperm candle burning 120 grains per hour, this being known as one candle-power. When such is completely burnt there is a yield of equal amounts of carbonic acid and water. The actual quantity is 0·43 of a cubic foot of each.

Electric light is unquestionably the best, as no air is required for combustion purposes, and consequently no products are evolved. It is cleanly and convenient. Being rich in ultra-violet rays, it closely resembles solar light. As evidence of this, plants grow and fruits ripen when exposed to its influence. For ordinary domestic purposes a glass bulb, exhausted of air and encasing a metallic filament, is most suited. The resistance of the wire to the passage of the current raises it to a condition of incandescence. For the lighting of streets and large buildings the arc light is commonly employed. Two carbon rods are brought into close opposition. By the action of the current the points are made so hot that a light of dazzling intensity is produced.

The light of coal-gas is due to the combustion of certain illuminants, such as acetylene, propylene and naphthaline. With the "batswing" and "fishtail" burners (the original types), no chimney is required, but in order to soften the light they are usually surrounded by globes of translucent glass. The principal products of combustion are carbonic acid, carbon monoxide, water, soot, sulphur, and ammonia compounds. A certain amount of heat is also generated, which must be regarded as a disadvantage. The composition of the gas is a matter of

5

great hygienic importance. The sulphur compounds, and more particularly carbon bisulphide, are mainly responsible for the unpleasantness of the air of gas-lit rooms. For this reason they should be removed as much as possible during the process of purification (*vide* p. 50). All fittings should be gas-tight. An escape is dangerous, not only because of the risk of an explosion, but on account of the carbon monoxide which coal-gas contains. Imperfect combustion also produces a large amount of injurious compounds. This is largely due to the varying pressure of gas in the mains. At one time of the day the pressure may be so slight as to furnish only a small flame, even when fully turned on. At another time, the pressure may be so great that the flame is flaring and singing. This obviously constitutes waste and produces an unduly large amount of unconsumed carbon. To control these variations governors are used. The governor, usually placed near the meter, automatically regulates the supply of gas by diminishing or widening the lumen of the pipe, according to the pressure.

For economical purposes water-gas is sometimes mixed with the coal gas. The carbon monoxide is thereby increased. In the event of a leakage the danger is therefore accentuated.

The Argand burner consists of a ring pierced at the top with small holes through which the gas issues. To regulate the supply of air a chimney is provided. In this way combustion is made more complete, as the air, in addition to surrounding the lights, can pass through the hollow cylinder formed by the gas flames.

The Welsbach incandescent burner is now largely employed. The non-luminous flame of a bunsen-burner is made to play on a mantle of asbestos gauze treated with sulphate of zirconium; incandescence results. The light is steadier and whiter than the ordinary gas flame, and consequently the illuminating power is higher. In addition to this advantage, the combustion of the gas is more perfect, and therefore the products are fewer. A cheaper form of gas can be used, one containing no illuminants, as heat, not light, is required.

The "Globe" and "Sunlight" gas-burners are sometimes used for ventilating as well as lighting purposes. They consist of ordinary gas flames, the products of which escape through a flue to the external air. The upward current thus created tends to remove the vitiated air from the building. They are placed in the roof, and are used more particularly for large buildings such as theatres.

Acetylene gas, C_2H_2, yields a good, steady white light. It is evolved by the action of water on calcium carbide ($CaC_2 + H_2O = C_2H_2 + CaO$). Its use, however, is attended with danger. The smell is pungent and very penetrating. Calcium carbide must be stored in a dry place, otherwise the gas may

be evolved. This is dangerous, as a certain admixture of gas and air produces an explosive compound.

The light of paraffin oil is due to the combustion of the vapour of hydro-carbons. The "flash point" is the temperature at which the vapour ignites. The danger of lamp explosions is due to the use of oils which have a low "flash point," and to the defective designs of the cheaper forms. A Select Committee appointed by Parliament recommended that the "flash point" should be raised from 73° F. (the limit laid down by the Petroleum Act of 1879) to 100° F. The London County Council made the same recommendation, and in addition suggested that the lamp should be strongly made, the reservoir in particular. The lamp should be kept clean and provided with a broad base to increase stability, an extinguisher to prevent the necessity of having to blow the flame out, and an arrangement by which the flame goes out if the lamp is overturned. The wick should be soft, reach the bottom of the reservoir, and just fit the wick tube. The hygienic disadvantages are the amounts of carbonic acid, soot, watery vapour, and heat produced.

Candles yield much unconsumed carbon, carbonic acid and aqueous vapour. Volatile products are also given off, due to the low melting-point of the wax.

The following table indicates the extent to which the atmosphere is affected by various forms of artificial lighting (from Notter & Firth)—

	Quantity consumed.	Candle power.	Oxygen removed.	CO_2 produced.	Heat calories produced.	Moisture produced.	Vitiation equal to adults.
			cub.ft.	cub.ft.		cub.ft.	
Tallow candles .	2200 grains	16	10·7	7·3	1400	8·2	12
Sperm candles .	1740 „	16	9·6	6·5	1137	6·5	11
Paraffin oil lamp	992 „	16	6·2	4·5	1030	3·5	7·5
Coal gas No. 5, batswing burner	5·5 cub. ft.	16	6·5	2·8	1194	7·3	5·0
Coal gas, Argand burner	4·8 „	16	5·8	2·6	1240	6·4	4·3
Coal gas, incandescent	3·5 „	50	4·1	1·8	763	4·7	3·0
Electric, incandescent	0·3 lb. of coal	16	0·0	0·0	37	0·0	0·0

SECTION IV

SOILS AND BUILDING CONSTRUCTION

THE top layer of the earth's crust, known as the soil, is derived from the growth and decay of animal and vegetable matter, and from the breaking down of rocks by the action of heat, cold, and water. It is constantly being transposed *in situ* by the canalising action of worms, and by the churning effect produced by moles, rabbits, and other burrowing animals. On the other hand, flowing water may carry, or cause to drift, disintegrated rocks of a nature totally different from that found locally. By bacterial action putrefactive and fermentative processes convert the organic matter into ammonia, sulphuretted hydrogen, carbonic acid, etc. The rain carries these compounds and organic matter, as such, into the earth. The soil thus presents a chemical composition of marked variation and complexity, and organic matter may be found only a few inches down, or at a depth of many feet. Soils are classified according to the amount of sand, gravel, clay, loam, and humus which they contain. Loam is a mixture of sand, clay, and humus in unequal proportions. It is termed light if sand predominates, and heavy when the clay is in excess. Humus is simply mould, that is, a substance containing the products of vegetable decomposition and certain acids, such as humic, ulmic, geic, and crenic.

At that depth where organic matter ceases to be present, the sub-soil commences. The sub-soils may be classified as, (*a*) sedimentary, (*b*) igneous, and (*c*) metamorphic. Those of the first order are generally stratified and consist of gravel, sand, clay, sandstones, limestones ($CaCO_3$ and $CaSO_4$), oolite (granular form of limestone), dolomite ($CaCO_3$ and $MgCO_3$), gypsum ($CaSO_4$), chalk ($CaCO_3$) and coal (carboniferous), etc. Of (*b*) granite and basalt are typical examples. These consist chiefly of felspar, which is a double silicate of alumina and potash. In addition they may contain iron oxides, lime, and phosphates. (*c*) Any rock which has been altered by pressure or chemical action is said to be metamorphic. Slates, mica, marble, quartz, and gneiss are examples. Alumina, silicates, lime, magnesium, and iron enter into their composition.

Temperature.—The temperature of the superficial layers of the

earth is affected by the external air. In all probability, however, the temperature 12 feet down is more or less a constant. As has been stated elsewhere, there is said to be a connection between the prevalence of summer diarrhœa and the temperature of the soil 4 feet below the surface. Dr. Ballard found that this disease was correlated, not with the air temperature, but with the soil temperature at that depth. The probable explanation of this is that, before the 4 foot earth thermometer can be affected, there must be a prolonged spell of hot and dry weather. At a depth of 100 feet, independent of latitude, the temperature is 52° F., followed by a rise of 1° F. for every 66 feet of further descent. The amount of heat a soil contains depends upon its power of absorbing and losing heat. If the amount absorbed by sand is represented by 100, then clay absorbs about 70, chalk 60, and humus 50. A moist soil is cold because of the high specific heat of the water which it contains. The amount of vegetation is also important, as trees check ground evaporation, and prevent the heat reaching the soil by the interception of the sun's rays. It is for this reason that such places are cold and wet in winter and cool in summer. Any evaporation which does occur, as from leaves, also causes an absorption of heat with consequent cooling.

Moisture.—All porous soils are either permeable or absorptive, but it does not follow that a permeable soil is an absorptive one. Sand, for example, is permeable, but its power of absorbing water is very limited. Sandstones, on the other hand, are not only permeable, but to some extent retain water. The dryness of the soil depends very largely upon these qualities. The more permeable a soil is, the drier it is. As a general rule, those which are most permeable are not absorptive, and consequently their storage capacity is small, and those which have a marked absorptive property are not very permeable. No soil is absolutely impermeable, even granite absorbs a little. The amount of rain which percolates into the soil is determined by factors other than mere porosity. Evaporation, hot winds, inclination of the soil, and the amount of rain flowing off the surface, are all concerned.

The water which rests on the first impermeable stratum is known as ground or sub-soil water. The level at which it stands is not a straight line, but assumes a curve according to the curvature of the earth's surface immediately above. The direction of flow depends upon the dip of the impermeable stratum which supports it. This also determines its velocity, along with the porosity of the soil, various impedimenta, as roots of trees, etc., and its proximity to natural outlets, such as rivers, etc. The rate of flow, however, seldom exceeds 50 feet in the 24 hours. Its fluctuations can be determined by an arrangement whereby a cord is made to move round a pulley. To one end of the cord

a float is attached which passes down a hole in the ground and rests on the water therein. This is counterpoised by a pointer at the other end of the cord. The float rises and falls with the varying levels of the water, and the amount of rise or fall is indicated by the pointer on a vertical graduated scale.

The air which fills the interstices of the soil above the ground water is called ground air. Its composition varies with the depth and the nature of the soil. As a rule it is poor in oxygen, rich in carbonic acid, saturated with moisture, and charged with organic matter. The moisture present is due to the percolation of rain and to the rising of ground water by capillarity. The carbonic acid results from the decomposition of organic matter, and the amount increases with the depth. The rain during its passage through the earth absorbs carbonic acid, and if chalk is the underlying stratum it is acted upon by the carbonic acid in the water, a bi-carbonate being formed. This is dissolved by the water, and thus in the course of time a fissure is created. After heavy rains the level of the ground water rises, and in so doing expels the ground air. For this reason it is advisable that the site of a house should be covered with a layer of concrete. The action of the wind, and sudden changes of atmospheric temperature and pressure, also have an aspirating effect upon soil air.

Bacteria.—The number of micro-organisms in the soil depends very largely upon the amount of organic matter, as experiments prove that the greater the organic pollution the greater the number present. Certain conditions, as warmth and moisture, favour their multiplication. The upper layers containing air are thronged with the ærobes, their numbers diminishing with the depth, or as the air decreases in amount. It may be stated as a general rule that, regardless of the chemical or physical composition of the soil, practically no bacteria are found below a depth of 15 feet. The varieties are saprophytic and pathogenic: of the latter, B. tetani, B. typhosus, B. anthracis, B. enteriditis sporogenes, and several forms of streptococci have been found.

In order to secure a healthy habitation certain conditions should be fulfilled. These may be classified as (*a*) an adequate supply of wholesome water; (*b*) a satisfactory system of refuse and sewage disposal; (*c*) a sanitary site; (*d*) a suitable aspect; (*e*) well-ventilated surroundings and (*f*) good house construction.

As to (*a*) and (*b*), these have been dealt with elsewhere.

(*c*) The **site** should be dry and unpolluted. A damp site favours the prevalence of such conditions as rheumatism, catarrhs, neuralgia, phthisis, and respiratory diseases generally. Sand, gravel and porous soils in general are good, as they are warm, and, as their power of retention is small, water easily runs away. Granite, chalk, sandstones and limestones are also good. They are naturally provided with a good slope, and so are quickly

drained. The clays are, generally speaking, bad, as they are damp and cold. A syncline of clay filled with sand or gravel, otherwise a "gravel pocket," is particularly undesirable, as almost invariably it is water-logged. Reclaimed land from the mouths of rivers, etc., is unhealthy, because of excessive dampness and presence of organic matter. Where sand or gravel has been excavated for building purposes, and the level made up by rubbish, the ground becomes a source of offensive effluvia and dust, as well as a breeding-ground for rats and flies. Such "made ground" is obviously unfit for building sites. In the process of time, however (three years at least), by natural agencies the soil becomes innocuous, and, provided it is well drained, may be built upon. In any event it is safer to dig into the ground some inorganic material, such as cinders, and to asphalt or concrete it over before building thereon. The level of the ground water is a matter of importance. It should not be liable to violent fluctuations, and preferably should never come within 10 feet of the surface. A moderately elevated spot will often secure these desiderata. A damp site may be rendered comparatively dry by a system of sub-soil drainage. A set of porous unjointed pipes is introduced at a depth to drain the sub-soil water. The pipes are laid end to end, with their joints resting on "cradles" and covered with "crowns" to prevent the soil getting in. This is always a useful expedient, as the ground water will seldom reach a level above that of the drainage pipes.

(*d*) **Aspect.**—Due consideration should be given to sunshine, wind and rain. On the longest day the sun rises in the north-east and sets in the north-west. On the shortest day it rises in the south-east and sets in the south-west. From this it follows that a northerly aspect receives the least amount of sunshine. For this reason kitchens, foodstores and the like should be placed on this wall. On the other hand, a south aspect receives the maximum amount of sunshine. Although in many respects this may be considered advisable, a wall so situated faces the sun during the hottest hours of the day, from 2 p.m. to 5 p.m. In view of this a south-easterly aspect is in all probability the best. The rooms most commonly used, and certainly the bedrooms, should therefore have a south-east aspect. In addition to this advantage the south-east is the dry quarter, it escapes the prevailing south-west wind and also the cold north-east wind.

(*e*) Outside London the **open space** around the building is controlled by special bye-laws, which the reader is advised to consult (see p. 290). On no account, however, should the street in front be narrower than the highest building, so that an angle of 45°, from the roof of one house to the wall at the ground level of the opposite house, is obtained. In that way, with streets running N.E. to S.W., the front-rooms of one side receive on an average about six hours sunshine per day. The actual amount,

of course, depends upon the time of the year. It is obvious that the front of only one side of such streets can face S.E., the most used rooms, therefore, of the other side should, as far as is practicable, be placed at the rear, so as to give them the south-east aspect. In London the London Building Act, 1894, governs the width of streets. The Act prohibits the raising of houses, in streets laid out since 1862, to a height greater than the width of the street, and, in other streets, higher than 80 feet, without the consent of the London County Council. The same Act determines the space at the back of the building. It says that the building shall come within a line drawn upwards at an angle of 63·5° from the rear boundary wall. This allows a building of a height of about 1·5 times the space at its rear to be erected. In the case of two houses, the rear boundaries of which back on each other, the angle formed between the ground level of one house and the roof of the other must be 45°. This is a great advantage, as it ensures a free circulation of air and more sunshine. Unfortunately it only applies to streets laid out since the passing of the Act. For those planned prior to the Act, 16 feet of vertical height above the level of the front street are allowed, before the diagonal line enclosing the angle of 63·5° is drawn from the rear boundary wall.

(*f*) By good **house construction** is meant freedom from dampness, strength, durability and fire resistance. Walls are usually constructed of bricks, stones and wood. A good brick weighs about 6 lbs. and measures about $9 \times 4{\cdot}5 \times 3$ inches. It should be made of well-burnt clay, regular in shape, free from flaws, absorb not more than one-sixth of its own weight of water, and when struck give a metallic ring. Mortar is composed of an aggregate and a matrix. The best aggregate is clean, sharp sand, the matrix consisting of either lime or cement. Lime mortar contains 1 part of lime to 2–3 parts of sand. It sets better and stronger if, when made, it is allowed to stand in a dry place for a week before using. Cement mortar is 1 part cement and 2–4 parts of sand. This is better used at once. If the setting process, once started, is disturbed, it does not reset with the same degree of strength. When a wall is built, wide courses or expansions, known as footings, are placed at its base to distribute the pressure of the super-imposed structure. There should be one footing for every half-brick the wall is thick, and the bottom one should in that way be twice the width of the wall. In order further to distribute the pressure, and to prevent dampness ascending the wall from the ground, a concrete foundation should be provided. The concrete layer must be 6 inches thick, but this really should be determined by the thickness of the wall. It should project laterally beyond the lowest footing by at least 6 inches.

The "bond" of a wall indicates the way in which the bricks

are laid. The English and Flemish bonds are the two mostly employed. The long side of a brick is known as the "stretcher" and the end as the "header." The English bond consists of alternate courses of "stretchers" and "headers," the Flemish of "stretchers" and "headers" alternately placed in the same course. Walls so bonded must be at least 9 inches thick. When a height of 25 feet or a length of 30 feet is exceeded, they are required to be of greater thickness. Internal walls should also be of brickwork, or made of some fire-resisting material, but lath and plaster partitions are permitted. They should be covered with hard, durable distemper, or washable paint. In the case of sculleries, bathrooms, larders, water-closets, etc., tiles or glazed bricks are highly recommended. Wall-paper harbours dirt, and is difficult to clean. Of the stones, limestone and sandstone are by far the commonest employed. Both are porous and absorbent, but to a less degree than bricks. The chief woods are ash, beech, teak, elm, oak, pine and deal. They should be well seasoned, and free from cracks and loose nuts.

As regards roofs, slates, tiles, wood, thatch, zinc, corrugated iron, lead and tarred felt are used. Slates should be hard, uniform in size and thickness, and absorb not more than 5% of water after immersion for twenty-four hours. Tiles are made of burnt clay, and are therefore more porous than slates, but they should be as little absorbent as possible. Thatch makes a good roof as such, but is dangerous from the point of view of fire, and because of its liability to be infested with vermin and birds. Wood, as a rule, is not watertight and is combustible. Zinc and iron are hot in summer and cold in winter. Lead is extremely heavy, and tarred felt, owing to its non-durability and inflammability, is not satisfactory.

Floors are made chiefly of wood, stones and tiles. They should be as impervious as possible, and washable. Stones and tiles are suitable for sculleries, pantries, etc., but wood, because it is warmer, is more commonly employed for living-rooms, etc. A parquet floor of oak or teak is exceptionally good. Deal, however, is much cheaper, and if laid free from cracks and crevices is quite satisfactory. With plain boards laid edge to edge, open joints are always liable to occur. The gaps thus formed become receptacles for dirt. In order to prevent this, the longitudinal edge of one board is provided with a "tongue," which closely fits into a groove in the longitudinal edge of the board next to it. Each board then has a groove in one edge and a tongue on the other. In that way, and if the wood is seasoned, and, therefore, not liable to shrink, a solid floor is obtained.

It is beyond the scope of this book to go into the details of fire-resisting construction; suffice it to say that, as far as possible, the materials used should be incombustible. Wood enters very largely into the ordinary roof, consisting as it does of rafters,

struts, slating battens, etc. To reduce the risk of fire spreading from the roof of one house to that of the next, the London Building Act lays down that the party wall, *i. e.* the dividing wall of two joined houses, shall project above the roof to a height of 15 inches. For the same reason no wood is allowed to be inserted in a party wall, unless between the centre of the wall and the wood there is at least half a brick. For large buildings reinforced concrete or ferro-concrete is being largely employed. This consists of ordinary concrete in which strips of iron are embedded. The introduction of the iron strengthens the concrete, inasmuch as the iron takes the tensile strain and the concrete the compressile. In addition to this, it renders the building more fire-resisting. Iron will not burn, but under the influence of great heat it will twist and buckle, thus endangering the stability of the building. No material is absolutely proof against fire, hence the advisability of using the expression "fire-resisting."

Dampness.—It has already been stated that the whole site of a house must be covered with concrete, in order to prevent the damp ground air gaining access to the building. Walls are liable to become damp in three ways: First, by dampness rising by capillarity through the wall from the ground; secondly, by dampness passing through the face of the wall, as by driving rains; and, thirdly, by dampness passing downwards through the wall from defective roofs, etc. To prevent the first cause, the wall must stand on a bed of concrete, and a layer of some impervious material must be inserted in the wall at a height of 6 inches above the ground level, but below the floor level. These damp-proof courses consist of either slates set in cement, a layer of asphalt, sheet lead, vitrified glazed bricks, or tarred felt. When the wall is in the course of erection, and the required height is reached, the slates, bricks, lead or tarred felt should be placed in position, or hot asphalt applied over the width and length of the wall. Slates are impermeable, but are not very satisfactory, as they are so liable to fracture. Glazed bricks and sheet lead are excellent. Tarred felt is not good, as in time it gets displaced and loses its impermeable property. The asphalt probably makes the best damp-proof course of all, on account of its uniformity and complete imperviousness. When exposed to the sun, however, it gets sticky and, by the weight of the wall above, is apt to ooze out.

Provision must be made for ventilating the space between the floor and concrete site, otherwise "dry rot" is apt to occur. The causal fungus (*Meringulus lachrymans*) is favoured by darkness and dampness. Wood so attacked very quickly rots, and floors often give way. A free current of air is preventive. For this reason ground floors should not be covered with linoleum, as by so doing the movement of air through the floor is impeded.

The means of ventilation is usually provided for by iron grids or perforated bricks. The above-mentioned glazed bricks, if perforated, can be made to play the dual rôle of a damp-proof course and ventilator. Where basements are concerned additional precautions must be taken. A satisfactory way of rendering them damp-proof is to excavate the earth to below the floor level, so as to leave a space, known as a dry area, between the vertical face of the earth and the basement wall. The area should be paved and drained by means of a gulley. An alternative plan is to have a double wall extending from below the basement floor level to about 6 inches above the ground. The hollow space, which should be 2·5 inches in width, prevents the dampness passing from one wall to the other. (See Fig. 16.)

This plan has the disadvantage of weakening the wall. It may be partly removed, however, by uniting the two walls by "wall ties." These consist of curved vitrified bricks or bars of

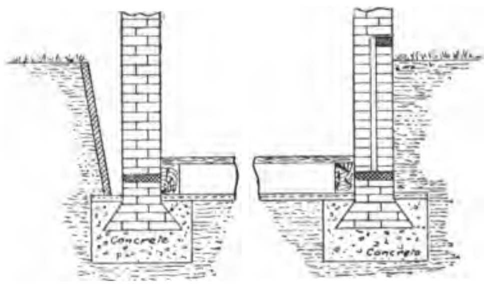

FIG. 16.—Diagram illustrating damp-proof courses.

zinc (not iron, as iron rusts) with their centres depressed in the shape of a **V** to prevent the passage of water from the wet wall to the dry. The bricks are curved for the same reason. Probably the best procedure of all is to asphalt the outside of the wall from the damp-proof course to the footings.

To prevent dampness passing through the face of the wall, two methods are employed: (1) Slates or tiles are made to hang on the front face of the wall; or (2) cement rendering. The latter method is the more common. A pleasing effect can be produced by what is known as "pebble dash." Small pieces of flint are thrown on to the wet cement, and when dry an impermeable indurated surface is obtained.

Defective rain-water guttering and pipes are the chief cause of dampness from above downwards. The obvious remedy is repair or renewal. Pipes should not touch the wall, as by so doing their backs cannot be painted. Rain is apt to rust a pipe, the rust crumbles away, and in the course of time a hole forms through which the water runs, the wall being made damp in

consequence. Paint, occasionally applied, tends to prevent this. Defective slating is another common cause. It is imperative that the slates should be laid in such a way, and with such a pitch (angle), that all rain is quickly removed to the gutter. Where the slates meet the party wall, or where a chimney passes through the roof, a junction should be effected between the party wall, or the chimney, and the slates, either by cement, or by means of an angular strip of lead, called a "flashing."

The top of a brick wall, if exposed, should be coped with stone. Mortar joints should be bevelled so as to throw off rain driven in an oblique direction. The under surfaces of window-sills should be grooved ("throating") along their greatest length. In that way the "continuity" is broken, the rain now being unable to pass along the under surface of the sill to the wall. The surface of the ground against the wall should be paved, with a slope away from the house. The wall itself should be cement-covered from the ground level to the damp-proof course. No earth, as flower-beds, should be banked up against the wall to a height above the cement rendering.

With newly-erected houses signs of dampness are almost certain to appear, due to the exudation of "building water." It makes itself evident by a streaky discoloration of the wall-paper, usually starting at the top of the wall. This condition must not be regarded seriously, as in the course of time it disappears. Dampness resulting from faulty construction generally starts at the bottom, ascending the wall by capillarity. In old houses, in order to conceal these signs, it is a common practice to panel up the lower half of the inside of the wall, such a condition therefore should arouse suspicion.

When large building schemes are under consideration, certain facts should always be kept in view. A house in a rural area must be provided with a large garden, not only for the purpose of vegetable growing and generally increasing the means of subsistence of the occupants, but as a place for disposing of house refuse, because, as a rule, no other method of scavenging is available. For this reason not more than four houses should be erected on one acre of ground. When urban areas are under review the question of transit is of considerable importance. It would appear from the evidence forthcoming that workmen are prepared to spend one and a half hours per day in travelling to and from their work. This fact, along with quick transit, should permit of schemes being put into operation at a distance from the town to relieve the congestion and the gregarious existence which many thousands are compelled to endure. The higher standard of living, and the demand that unnecessary drudgery should be reduced, call for improved methods of heating, better hot-water systems and labour-saving arrangements in the home. For the working classes each house should be self-contained,

although blocks of buildings containing a series of tenements are the cheapest form, as no less than 1500 people can be accommodated per acre. On the score of health this arrangement is to be deprecated, as a condition of overcrowding is liable to ensue. In order to prevent overcrowding of houses, on one acre of ground not more than twelve should be erected. This will allow the superficial area of each house to be increased beyond the standards generally accepted, the additional expenditure being met, when possible, by the use of less costly materials and improved methods of construction. Wide fronts permit of a separate bathroom, bedrooms of an adequate size, and more air and sunshine, and reduce the difficulty when the aspect is under consideration. According to the Report of the Women's Housing Sub-Committee to the Minister of Reconstruction, each house should contain three rooms on the ground floor, living-room, parlour and scullery, and three rooms above, two being capable of taking two beds. A larder and a bathroom are essential. The bedrooms should be well lighted by a window in an external wall. A fireplace should be provided in each, except for the smallest bedroom, where other means of ventilation must be substituted. The minimum cubic space allowed for each adult should be 500 cubic feet, and 250 cubic feet for each child under 10 years of age. The living-room should be as large as possible, well lighted, and contain a closed-in dresser. A parlour is necessary, as in its absence other rooms are used as such. The bathroom should be separated, in order to secure complete privacy. Hot and cold water and a lavatory basin should be provided. Whether the bathroom is upstairs or downstairs should depend upon the wishes of the people. If placed upstairs bedroom space is forfeited, and from the economic point of view it is more expensive, as a greater length of piping is required. The scullery should be of such a size as to hold all necessary fittings and utensils, and to allow free movement. It should be well lighted, and hot water should be laid on. The larder should have a north or east aspect, be well lighted, and ventilated by a window on an outer wall. The flooring and walls should be of some cleanly and non-absorbent material. It should also contain a slab of stone or other suitable material, and adequate shelving. Stairs should permit of the easy passage of furniture, and be lighted by an easily-opened window. The water-closet, if other arrangements cannot be made, should be downstairs in a well-ventilated back lobby, or outside, approached under cover, screened and well ventilated. The coal store should be reached under cover, and be of such a size as to hold at least one ton. An outhouse is advisable for the storage of bulky articles. It should not obstruct the light. A garden is a *sine quâ non.*

The choice of windows for bedrooms, etc., should depend upon local preference. Casements are generally unsuitable in windy

or exposed places, as they are difficult to make waterproof. Where used they should be fitted with a push-out fanlight at the top, and the side windows should open in reverse directions. The top should be not more than 9 inches from the ceiling, and the whole not less than one-tenth of the floor area; whether sash or casement is used, the window should be accessible for cleaning purposes.

So far as central heating is concerned, if applied to groups of houses, the system is labour-saving, economical of fuel and heat, and would, if brought into general use, reduce the amount of smoke in the atmosphere. Objection is made, however, on the grounds of health, but in all probability this could be removed with improved methods of ventilation. In large schemes it is possible to combine electric lighting and central heating plants, utilising the waste heat from the generator, and saving cost in the upkeep by making dual use of one engineering staff. Waste heat from factories might also be utilised. The chief difficulty of heating a small group of houses is arranging for the stoking of the furnace. For individual houses the cooking-stove, in addition to providing hot water for the bath and sink, might also serve radiators in the parlour and living-room. In that way all three rooms would be habitable at a cost, in fuel and labour, of one fire. When the cooking range is not in use a small coal or gas fire can be lit in the living- or sitting-room. In all cases where radiators are used each one should be provided with a regulator.

For lighting purposes, electricity or the incandescent gas burner is the best.

In **house inspection** the following represent the principal points which should be observed—

Situation of the premises.
Owner's name and address.

Approaches and Surroundings.—Note the proximity of other buildings and trees which might impede ventilation, or shut out light and sunshine. Tall factory chimneys, offensive trades and other sources of effluvia, stables, etc., stagnant water and accumulations or deposits of decomposing organic matter.

The front of the house should then be inspected: detached, semi-detached, or one of a terrace, provided with a garden, width of street, etc. The general appearance and obvious defects should also be noted. Particular attention should be given to the roof, as to condition, party walls, flashings, rain-water gutterings and pipes. The rear should be examined on similar lines with additional points, such as the paving of the yard, whether suitably drained to a trapped gulley; whether animals are kept, how they are kept, and their distance from house; means of storing household refuse, whether sanitary and where kept.

The Interior.—Note whether back-to-back, number and size

of rooms, window space, whether the windows open, other means of ventilation, fireplaces, cleanliness, signs of dampness, basements (whether used as cellar dwellings), heating arrangements and general condition of repair. Ascertain number of families (if let out in tenements), number in each family, sex and age, the lighting and condition of staircases and passages, etc.

Sanitary Arrangements.—Note whether water-closets or earth-closets, etc., and their number. If water-closets, where placed, lighting, ventilation, what type, sufficient flush, source of flush, properly trapped, cleanliness, and privacy. If earth-closets, etc., where placed, etc.; in addition, dimensions of receptacle, materials, water-tight, arrangements for applying dry earth to the excreta, access for scavenging, etc.

Condition and position of soil-pipe, provision of anti-siphonage pipes, sufficient height above the eaves, nearness to windows, etc., size, course, and ventilation. Note whether sink, bath, and lavatory wastes are suitably trapped. The course and construction of these waste-pipes and their disconnection from the main drain. Rain-water pipes, general condition and destination. Gullies for receiving wastes and rain water, their trapping and general efficiency. Number and situation of inspection chambers, and means of access. The course, size, material, fall and ventilation of the main drain, its disconnection from the sewer by an "intercepting" trap, the position of the mica-flap fresh air inlet, and the soundness of the drain as tested by water, smoke or other means.

Water Supply.—Note whether constant or intermittent, number of taps and where placed; material, construction, cleanliness and accessibility of cistern: whether cistern is provided with an overflow pipe discharging in the open air, and any connection with the water-closet. If in a rural area, note whether from well, spring, river, etc., also adequacy, purity, distance from house, obvious sources of pollution. If from well, note depth, construction, cover, and number of houses supplied.

Dampness.—Note whether damp-proof course exists, if so, of what kind, ventilation of space between floor and ground, banking of earth against walls, dryness of basement, dry area, concrete site and foundations, and general soundness and thickness of walls.

SECTION V

FOOD

DIETS

THE human body requires a diet containing in their proper proportion proteins, fats, carbohydrates, organic and inorganic salts, water, and what are known as accessory food factors or vitamines.

(*a*) **Proteins** are converted in the stomach into albumoses and peptone, and these are changed in the intestine into amino-acids and other " end-products," by the action of trypsin and erepsin. Unless the protein ingested corresponds with the protein required by the body, it cannot be used for the formation and repair of tissue. Thus the proteins of milk and animal flesh will maintain life in smaller amount than vegetable protein. The main functions of protein are: 1. To supply energy—only about three-quarters of the total energy, however, is utilised. 2. To furnish the raw material necessary for the growth and repair of tissue. 3. To increase the rate of chemical change in the body, and thus facilitate the utilisation of other foods.

(*b*) **Fats** are first emulsified in the intestine and then broken up into glycerine and fatty acids by steapsin. They are the greatest heat or energy producers, and they also aid in the formation and storage of fat in the body.

(*c*) **Carbohydrates** are first acted on by the saliva, and finally converted into monosaccharides by the pancreatic ferments. They are stored as glycogen in the liver, and serve as a source of heat and energy, though to a less extent than the fats.

Carbohydrates are divided into three groups—

1. Monosaccharides or Glucoses ($C_6H_{12}O_6$), including dextrose (grape sugar), lævulose (fruit sugar) and galactose. They reduce Fehling's solution and are fermentable with yeast, thus—

$$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$$

2. Disaccharides or Sugars ($C_{12}H_{22}O_{11}$), including saccharose or sucrose (cane sugar), lactose (milk sugar) and maltose. The two last reduce Fehling's solution. Saccharose, when boiled with a dilute acid, is changed into Invert Sugar or a mixture of dextrose and lævulose, both of which reduce Fehling's solution.

3. Polysaccharides ($C_6H_{10}O_5$), including starch, dextrin, glycogen, and cellulose. Boiling with a dilute acid converts these into monosaccharides capable of reducing Fehling's solution.

(*d*) **Salts.**—Organic salts such as tartrates and citrates are converted into carbonates in the body, and help to maintain

the alkalinity of the various fluids. Inorganic salts, such as phosphate of lime, sodium chloride, etc., enter into the composition of all tissues and fluids.

(*e*) **Water** forms over 60% of the weight of the body. A loss of 10% may prove fatal.

Vitamines or Accessory Food Factors.—Without these, "deficiency diseases" such as scurvy, beri-beri and rickets are liable to occur. Their composition is unknown, and their presence can be detected only by animal experiment. Three such substances are now recognised.

(*a*) Antineuritic or anti-beri-beri vitamine (water-soluble B. growth factor).

(*b*) Antiscorbutic vitamine.

(*c*) Antirachitic vitamine (fat-soluble A. growth factor).

Most of the work on this subject has been collected by the Committee on Accessory Food Factors, and a memorandum was published in the *Lancet* of July 5, 1919.

(*a*) **Antineuritic Vitamine** is present in most natural foodstuffs, especially in the germ of cereals and to a less extent in the outer husk, in pulses, in eggs of animals, in cellular organs such as liver and brain, and in yeast and yeast extracts. Flesh contains little. Polished rice and white flour are deficient in this respect on account of the modern methods of milling. This vitamine resists drying and can withstand a temperature of 100° C. for two hours. Beri-beri develops in 80–90 days in persons living on a diet deficient in such content.

(*b*) **Antiscorbutic Vitamine** is present in active, living vegetable tissue. It is found chiefly in vegetables such as cabbage, swedes, turnips, etc., and in the juices of lemons, oranges, tomatoes, etc. Potatoes contain less. Meat and milk have a small but definite value. It is destroyed by drying, heating, and other methods of food preservation. Hence tinned food contains little or none. Dried pulses steeped in water, and allowed to germinate, are rich in this vitamine. Scurvy develops in about four months if this vitamine is absent from the diet.

(*c*) **Antirachitic Vitamine** is derived chiefly from animal fats, *e. g.* butter-fat, beef-fat, fish oils, and egg yoke, and from green leaves. It is lacking in most vegetable oils with the exception of pea-nut oil. Hence margarine is of much less nutritive value than butter. It is important to remember that nursing mothers must have an adequate supply of accessory food factors, otherwise the breast-fed child may develop rickets or scurvy.

In addition to supplying the body with material for the growth and repair of tissues, food constitutes the fuel or potential energy which is converted into work or actual energy. Potential energy is measured in terms of heat units or calories—a calorie being the amount of heat required to raise the temperature of one kilogram of water 1° C. The following calorific values have been determined by calorimeter—

1 gram of dry protein		=	4·1 cals.
1 ,, ,,	carbohydrate	=	4·1 ,,
1 ,, ,,	fat	=	9·3 ,,

This energy, in terms of heat, can be expressed also in terms of work: 1 calorie is equivalent to 425 kilogram-metres, or actual energy necessary to raise 1 kilogram a height of 425 metres.

Food Requirements of the Body.—(*a*) The expenditure of energy by the body may be estimated by enclosing an individual in a special room which acts as a calorimeter, inasmuch as all the energy given off by the inmate is converted into heat and measured in calories. Another method is to determine the amount of CO_2 exhaled and reckon the energy which must have been used up in this oxidation process. Results obtained by these means are very similar, and the following figures are some that have been worked out—

1. Maintenance of body functions.	
In bed fasting	1700 cals.
In bed feeding	1850 ,,
2. Sedentary life in a room . . .	2170 ,,
3. Sedentary life—including walk of $1\frac{3}{4}$ miles in one hour	2500 ,,
4. Light work	3000 ,,
5. Moderate work	3500 ,,
6. Hard work	4000 ,,

An average day's work is usually taken to be about 100,000 kilogram-metres (300 foot-tons), representing an expenditure of 232 calories. This amount is, of course, over and above the energy spent in maintaining metabolism, etc. Considerably more than 232 calories are, however, actually expended, as the body, in the performance of external work, utilises more energy than is theoretically calculated to be necessary.

(*b*) Knowing the expenditure of energy of the body under various conditions, we are in a position to arrange for dietaries to meet the requirements.

Diets must contain the various nutritive principles in their proper proportions. As a rule, protein should amount to from 100–120 grams daily for the average adult doing even light work. Chittenden in America endeavoured to prove that ordinary active life could be satisfactorily maintained on about 50 grams, and that protein much in excess of this was liable to cause harm. Rubner has stated that nitrogenous equilibrium can be maintained so long as 5–6% of the total calories in the diet are furnished from protein—*i. e.* an adult male doing sedentary work requires a minimum of 30–35 grams of protein daily. Such protein must, of course, be as completely assimilable as possible. The fact remains, however, that most of the virile races in the world consume a diet fairly rich in protein, and experience in the European War has shown that for sustained effort under trying conditions protein is not replaceable by any other food principle.

Fats and carbohydrates bulk largely in the diets of the poorer classes. It must be remembered that 1 gram of fat is equal to $2\frac{1}{4}$ grams of carbohydrate, as a source of energy, while carbohydrates have rather more protein-sparing powers than fats. A satisfactory ratio of fat to carbohydrate is 1 to 5.

From these considerations we can lay down the average composition of a working-man's diet as—

Protein	100 grams.
Fat	100 ,,
Carbohydrate	500 ,,
	3400 calories (about).

It is important to remember that all food digested is not utilised by the body. Thus, in a mixed diet, about 92% of the protein, 95% of the fat, and 98% of the carbohydrate are actually digested. The rest goes to waste in the fæces. In preparing food for the table a further amount is lost. Hence, a diet should have a greater calorific value than is theoretically demanded by the actual work done by the consumer.

In very hard work, all the figures would have to be increased, but the amount of proteins and fats should be raised proportionately more than that of carbohydrate. It is unusual to find in any diet more than 200 grams of protein, 150 grams of fat, or 600 grams of carbohydrate.

It must not be forgotten that a sufficiency of fluids and salts must be allowed, and provision must be made for the inclusion of accessory food factors. In addition bulk is an important factor in diets. It is possible to administer, in almost tablet form, a diet of the requisite calorific value, but for the proper functioning of the intestine undigested residues are required.

The following table shows the proportions in grams of nutritive principles, and the calorific values, of various diets—

	Protein.	Fat.	Carbo-hydrate.	Calories.
British Army Field Ration	128·16	171·51	489·12	4129
,, ,, Iron Ration	146	46·5	440·8	2841
,, ,, Male Hospital Staff	94·3	108·9	445	3225
,, ,, Female Hospital Staff	78·2	98·7	363·8	2731
Voluntary Male Civilian Ration during the War—				
(*a*) Sedentary Work	48·7	61·6	221·3	1680
(*b*) Medium ,,	61·7	63·5	306·3	2099
(*c*) Heavy ,,	66·9	64·3	340·2	2268

The first four sets of figures have been taken from the handbook *Army Rations—their Bearing on the Efficiency of the Soldier*, by Noel Paton.

The following table, compiled by Prof. W. H. Thomson, is taken from *The Food Supply of the United Kingdom* (Cd. 8421, 1917)—

Analysis used.	Protein. %	Fat. %	Carbo-hydrates. %	Energy value per kilo.
Bread	7·3	0·2	47·2	2246 cals.
Cereals—				
Wheat flour	11·4	1·0	75·1	3639 ,,
Oatmeal	16·1	7·2	67·5	4098 ,,
Barley meal and flour	10·5	2·2	72·8	3620 ,,
Maize meal	7·5	4·2	65·9	3400 ,,
Rice	8·0	0·3	79·0	3595 ,,
Meat—				
Beef (home)	14·5	22·5	—	2687 ,,
,, (foreign)	15·0	18·0	—	2289 ,,
Mutton (home)	13·5	25·0	—	2879 ,,
,, (foreign)	13·0	23·9	—	2756 ,,
Pork (home and foreign)	10·0	40·0	—	4130 ,,
Bacon (foreign)	9·5	59·4	—	5914 ,,
Hams (foreign	14·5	33·2	—	3682 ,,
Meat (preserved)	25·5	22·5	—	3138 ,,
Poultry, game and rabbits	20·7	8·3	—	1621 ,,
Dairy Products, Eggs, etc.—				
Milk	3·3	4·0	5·0	712 ,,
Condensed milk, sweetened	8·8	8·3	54·1	3351 ,,
,, ,, unsweetened	9·6	9·3	11·2	1718 ,,
Cheese	25·0	30·0	2·4	3913 ,,
Margarine	1·2	83·0	—	7768 ,,
Butter	1·0	85·0	—	7946 ,,
Eggs	11·9	9·3	—	1353 ,,
Vegetables—				
Potatoes (20% allowed for waste)	1·8	0·1	14·7	686 ,,
Onions (10% allowed for waste)	0·5	0·1	5·5	255 ,,
Tomatoes	0·9	0·4	3·9	234 ,,
Peas, green, in pods (45% waste)	3·6	0·2	9·8	568 ,,
Peas, beans, lentils (dried)	24·3	1·3	60·3	3590 ,,
Beans, green, in pods	4·7	0·3	14·6	819 ,,
Carrots (20% waste)	0·9	0·2	7·2	351 ,,
Turnips (30% waste)	0·9	0·1	5·7	280 ,,
Green vegetables (15% waste)	1·6	0·38	4·2	273 ,,
Fruit—				
Apples (25% waste)	0·3	0·3	10·8	483 ,,
Bananas (35% waste)	0·8	0·4	14·3	656 ,,
Oranges (27% waste)	0·6	0·1	8·5	382 ,,
Nuts	6·4	22·5	5·25	2569 ,,
Fruit, dried	2·34	2·18	70·9	3206 ,,
Sugar and Molasses, etc.—				
Sugar, refined	—	—	100·0	4100 ,,
Cocoa and chocolate	15·0	26·0	30·0	4263 ,,
Fish, fresh—				
Herring (42·6% waste)	11·2	3·9	—	822 ,,
Haddock and Cod (52% waste)	8·4	0·2	—	363 ,,
Salmon (34·9% waste)	15·3	8·9	—	1455 ,,
Fish, canned, cured, etc.—				
Sardines	23·7	12·1	—	2097 ,,
Salmon	19·5	7·5	—	1497 ,,

When the calorific value of a diet is desired, the percentage amount of protein, fat, and carbohydrate in each article of food must be multiplied by 4·1, 9·3, and 4·1 respectively. The sum will give the calorific value per 100 grams of the food. To express this as so much energy per pound, divide by 0·22.

The following practical points in arranging diet scales must not be overlooked—

1. **Age.**—In a mixed population of men, women and children, each individual should be reckoned as 0·7 man; children from 0–5 years equal 0·4 man, from 6–9 years 0·5, from 10–13 years 0·6, and from 14–15 years 0·7 (females), and 0·8 (males).
2. **Sex.**—Reckon a woman of 16 years and over as 0·8 man.
3. **Type of Work.**—Brain workers as a rule should have easily digestible food.
4. **Climate.**—Cold climates demand more fats and probably more proteins; hot climates more vegetable foods.
5. **Local Prices.**
6. **Digestibility** of the food selected. Animal food is generally more completely digested than vegetable. This also implies good cooking.

A diet yielding approximately 3500 calories could be composed of the following substances—

			Calories per gram.	Total calories.
Home Beef	227 grams	(8 oz.)	2·687	610
Bread	454 „	(16 oz.)	2·253	1023
Margarine	57 „	(2 oz.)	7·768	443
Rice	57 „	(2 oz.)	3·595	205
Cheese	57 „	(2 oz.)	3·913	223
Milk	567 „	(20 oz.)	0·712	404
Potatoes	454 „	(16 oz.)	0·686	311
Sugar	57 „	(2 oz.)	4·1	234
				3453

Cooking of Food is undertaken principally to make it more palatable and to facilitate digestion. Thus heat coagulates albumen and ruptures the capsules of starch granules. In addition it tends to destroy any harmful organisms and their products. It is important to remember that boiling or roasting, while it sterilises the surface layers, will not kill organisms in the centre of a roll of meat more than 3 or 4 lbs. in weight. A temperature of 60° C. is rarely reached in the centre of a joint of 6 lbs. or over. Boiling is, of course, the safest method. Only prolonged cooking will ensure the destruction of parasites, or micro-organisms, and their products.

The reader is referred to the small Army Handbook already quoted, to a report on *The Food Supply of the United Kingdom* (Cd. 8421, 1917), and to Nos. 13 and 38 of the Special Report

Series of the Medical Research Committee, for further practical information on the subject of diets.

MILK

Percentages

	Fat.	Sugar.	Proteins.	Ash.	Water.
Human	3·4	6·4	1·7	0·3	87·2
Cow	3·7	4·7	3·4	0·75	87·3
Goat	4·63	4·22	4·35	0·76	86·04
Ass	1·26	6·5	1·66	0·46	90·12

Human Milk as compared with cows' milk—

1. Less total proteins, about the same amount of lactalbumin, but considerably less caseinogen. The clot is less coarse and more easily digested.
2. More lactose.
3. More iron.
4. May contain antibodies or protective substances.

Cows' Milk.—The amount and quality of milk vary according to—

1. **The Breed of Cow.**—Kerry cows and Jerseys give most fat, Shorthorns and Holsteins the greatest amount of milk. The average yield of milk per cow amounts to 400–500 gallons a year.
2. **The Age of the Cow.**—The best milk is given from the fourth to the seventh year. The greatest amount is said to be given from the fifth to the seventh calving. The first calf is born usually in the third year.
3. **The Stage of Lactation.**—During the first week after calving milk should not be used for human consumption, on account of the presence of colostrum. Most milk is yielded during the five months following.
4. **Time of Milking.**—Morning milk is poorer in fat than evening milk, but somewhat greater in quantity.
5. **Stage of Milking.**—The last milk, or "strippings," is nearly pure fat. "Fore-milk" is thin.
6. **The Feeding.**—Nitrogenous foods increase the percentage of fat, and usually increase quantity as well. Roots tend to increase the sugar. Too much oilcake and brewers' grain produce a poor milk. An alteration in the colour and taste of milk may sometimes be traced to the use of unusual foodstuffs. The best food is natural grass and hay.
7. **Season of the Year.**—In May and June fat tends to be low. In July and August the non-fatty solids fall. In the last quarter of the year both these figures are highest. In a dry season the fat increases and the non-fatty solids decrease.
8. **Health of the Cow.**—Colostrum produces a yellow colour in milk. Tuberculosis is accompanied by watery milk. Foot

and mouth disease and mastitis lower the quantity and increase the cellular elements. In other diseases the secretion may cease altogether.

By a proper selection of the cows in a milk herd, it is possible to obtain milk that will comply with all legal standards throughout the whole year. A dairyman has no right to aim merely at quantity, without due attention to quality.

The Reaction and Clotting of Milk.—Fresh milk is amphoteric, due probably to the acid phosphates of alkalies. When sold, milk is usually acid. When the acidity amounts to 0·4% lactic acid, it is appreciable to taste, and when it reaches 0·6% the milk curdles. Souring is due to the formation of lactic acid from lactose by such organisms as B. ac. lactici and B. coli. The curd contains most of the protein and fat, and the whey most of the remaining lactose, the lactalbumin and salts. Milk may, of course be curdled, by the addition of rennet. This first changes caseinogen into soluble casein, which unites with calcium salts to form an insoluble combination or clot. The addition of sodium citrate to cows' milk (2 grains to the ounce) precipitates some of the calcium salts and produces a more flocculent clot; hence the frequent adoption of this practice in infant feeding. Milk containing 0·4% sodium citrate will not curdle at all with rennet.

Fat.—Milk fat is composed mainly of the glycerides of butyric, palmitic and oleic acids. It is present as globules of various sizes, and, on standing, rises to the surface as cream. The larger globules ascend first, and in about eight hours over 60% of the fat rises. It is important to remember that most of the bacteria in milk ascend with the cream. The fat emulsion is destroyed by pasteurisation or homogenisation (the fine division of the fat globules by spraying on agate knife edges), hence the familiar cream tube test gives frequently no indication of the real amount of fat in a sample of milk. The natural colouring matter of milk (lipochrome) rises with the fat and a bluish fluid remains. The legal standard for fat in milk is 3%. (Sale of Milk Regulations, 1901, issued by the Board of Agriculture.) When milk is hand-skimmed or machine-separated, most of the fat is removed, only about 1% of fat remaining in the former case and 0·2% in the latter.

Protein.—Caseinogen forms about 3%, lactalbumin about 0·4% and lactoglobulin the remainder. Altogether there is about 3·5% of protein in milk. While caseinogen is acted on by acids and rennet and a clot formed, lactalbumin remains unaltered. Lactalbumin is, however, coagulated when heated to 70° C.

Lactose.—($C_{12}H_{22}O_{11}$) is present in the milk of all mammals. It is soluble in water, but not in ether, and is changed by boiling with a dilute acid (but not citric acid) into galactose and glucose. It reduces Fehling's solution.

Salts.—Milk contains soda, potash, and calcium in combination

with chlorine, phosphoric acid, sulphuric acid, etc. Traces of iron exist also.

A standard of 8·5% has been laid down by the Sale of Milk Regulations, 1901, for non-fatty solids in milk. In skimmed milk the figure of non-fatty solids must not be below 8·7% (Sale of Milk Regulations, 1912).

Enzymes.—All enzymes are catalytic in action, that is, they have the power of accelerating chemical velocity. They are divided into groups according to the nature of the substances (the substrate or zymolite) on which they act. Thus, those acting on starch are called amylolytic, on protein proteolytic, and on fat lipolytic. They are specific in their action, *e. g.* lipase acts only on fat, not on starch or protein. They are inexhaustible in their power, as a small amount will act on an unlimited quantity of substrate. Their chemical composition is unknown, but they are probably colloidal proteins, or closely akin to protein. They are colloidal because they are non-diffusible, and protein because they have an optimum temperature. They are destroyed by heat, for their power to work does not return when the temperature is again lowered to the optimum.

Nearly all the enzymes in milk are of bacterial origin, *e. g.* catalase, reductase and proteolytic ferments. Peroxidase is considered to be derived mainly from leucocytes. There are no grounds for claiming any biological value for these ferments (L.G.B. Report, New Series, No. 76, 1913).

The Cellular Elements in Milk.—A good deal of discussion has taken place regarding the importance of cell-counts in milk, and so far no satisfactory standard has been laid down. Normally various types of cells may be present. They have been divided into three main groups: (1) large mononucleated cells; (2) multinucleated cells; and (3) small mononucleated cells.

Eosinophile cells and large vacuolated cells may also be detected. The majority are probably glandular in origin, but a certain proportion are possibly true leucocytes from the blood-stream. More cells are present in the strippings than in the fore-milk. While colostrum is present in the milk, a large number of cells filled with fat globules, or colostrum corpuscles, appear. Their origin is equally in doubt, though the theory that they are really leucocytes has been put forward. In any case the cell-count is usually greater during this period. In the later stages of pregnancy the larger cells usually increase in number, and towards the end of lactation the total cell-count rises. The principal cause of an increase in the number of cells is mastitis, the majority of the cells being leucocytic in type. When such an increase is associated with the presence of streptococci the condition is of significance. In Boston U.S.A. a leucocyte count of over 500,000 per cubic centimetre is considered suggestive of mastitis, especially if streptococci are present as well.

Various methods have been employed for estimating the number of cells. Savage adds Toison's fluid to 1 c.c. of milk and centrifugalises (1800 revolutions per minute) in a tapered tube. The cream is broken up by means of a glass rod and a second period of centrifugalisation given. The supernatant cream and fluid are removed down to the 1 c.c. mark, and the cells present in the remaining fluid counted in a Thomas-Zeiss apparatus.

Dirt in Milk.—Dirty milking, faulty methods of transit, and bad handling generally account for the presence of dirt in milk. It is largely manurial in origin. It may be estimated by allowing a known quantity of milk to stand for a certain length of time (or else centrifugalising it) and weighing the residue. Thresh suggested a standard of 3–5 milligrams per litre, for a clean milk. Houston advocated: (1) On standing, the measurable amount of dirt should be less than 10 parts per 100,000. (2) When this residue is diluted with water and centrifugalised, the volume should be less than 5 parts per 100,000.

It must be remembered that a considerable amount of the dirt that enters milk is probably dissolved, and what remains to be measured after a certain number of hours may be only a fraction of what was originally present.

Bacteria in Milk.—Large numbers of organisms are always present in milk, however carefully handled. From the moment milk is drawn from the cow's udder it is liable to receive gross bacterial contamination and, as milk forms the best possible medium for growth, the numbers proportionately increase. More especially is this the case if the milk is not cooled. Millions of bacteria per cubic centimetre may be present within a few hours of milking, unless every possible precaution is taken. Milk in the udder of a normal cow contains few or no bacteria. All are added either as a result of some disease process in the udder of the cow, or else through dirty external conditions. In mastitis the causative organisms are found in milk, *e. g.* streptococci, staphylococci, etc. The micrococcus melitensis, B. tuberculosis in tubercle of the udder, and the ultra-microscopic virus of foot and mouth disease may be present. Top-milk contains many times the number of organisms found in the remaining portion of the milk. "Ropy milk" is due to the presence of various organisms, especially B. lactis viscosis and certain streptococci. Such a condition is difficult to deal with in a dairy once it has gained a footing. It is not actually injurious to health.

Effect of Heat on Milk.—The only change that occurs in milk heated at 60° C. for half an hour is that the lactalbumin begins to coagulate. At 70° C. some alteration of the fat emulsion takes place, and the familiar taste of heated milk begins to appear. At this temperature a skin forms, composed mainly of lactalbumin.

Boiled Milk.—1. Protein is altered, caseinogen being made

more digestible, and albumin coagulated. Rennet coagulation of caseinogen is delayed.

2. Some of the calcium and magnesium salts are precipitated, and a portion of the citrate is lost.
3. Some of the phosphorus is precipitated.
4. CO_2 and other dissolved gases are driven off.
5. Fat emulsion is destroyed, the globules tending to coalesce.
6. Destruction of enzymes, and all micro-organisms (only on prolonged boiling).
7. Partial loss of vitamines.
8. Partial caramelisation of lactose.

Pathogenic bacteria are killed at temperatures lower than 100° C. At 60° C. B. tuberculosis is killed in twenty minutes, B. typhosus in two minutes, B. diphtheriæ in one minute, spirillum choleræ in one minute, B. dysenteriæ in ten minutes, and micrococcus melitensis in twenty minutes. A skin must not be allowed to form on the milk or those results will not be obtained. A skin may be obviated by the use of a closed vessel or by constant stirring. Milk with a total bacterial count of about 2,500,000 per cubic centimetre shows only some 20,000 after pasteurisation for half an hour at 60° C.

Grading of Milk.—The growing demand for pure milk has resulted in the grading of milk, mainly in accordance with bacteriological standards. In the States considerable progress has been made and the following grades are met with—

"**Certified Milk**" means milk produced by cows certified as free from disease, after physical examination and tuberculin test, by a qualified Veterinary Surgeon. The milkers must also be free from all disease and must not be carriers of any pathogenic organisms. The whole process of milking and handling the milk must be rigidly controlled, and the premises, etc., must be open to inspection by the Sanitary Authority. As soon as the milk is obtained it must be cooled, filled into sterilised bottles, and kept below 10° C. till delivered. It should not contain more than 10,000 bacteria per cubic centimetre and should be delivered within thirty-six hours of milking.

It is not considered possible to insist on such a standard in this country. In America the universal use of ice makes easier the delivery of milk at low temperatures.

In 1914, New York State issued regulations grading milk as follows—

Grade A. Raw.—Must at no time prior to delivery contain more than 60,000 bacteria per cubic centimetre (or the cream more than 300,000 per cubic centimetre). Must be delivered within thirty-six hours of milking in vessels sealed at the dairy. Must be labelled with the name and address of the dairyman, and the grade. Herds supplying Grade A. milk must be free from

tuberculosis, as demonstrated by the tuberculin test within the previous year.

Grade A. Pasteurised.—Before pasteurisation must not contain more than 200,000 bacteria per cubic centimetre in the cream or milk. After pasteurisation must not contain more than 30,000 bacteria per cubic centimetre in the milk, or 150,000 per cubic centimetre in the cream. Delivered as in the foregoing and labelled " Grade A. Pasteurised."

Grade B. Raw.—Prior to delivery must not contain more than 200,000 bacteria per cubic centimetre in the milk, or 750,000 per cubic centimetre in the cream. Otherwise as in Grade A. Raw. Herds supplying this grade must, on physical examination, show no signs of disease.

Grade B. Pasteurised.—Not more than 300,000 bacteria per cubic centimetre in the milk or cream prior to pasteurisation, and at any time after pasteurisation not more than 100,000 per cubic centimetre in the milk or 500,000 per cubic centimetre in the cream. The milk must be delivered within thirty-six hours of pasteurisation, and the cream within forty-eight hours —in containers suitably labelled.

Grade C. has no bacterial standard, but the milk must be delivered within forty-eight hours of milking or pasteurising, as the case may be.

In all grades, of course, the milk must comply with any chemical standards laid down. The bacterial standards refer to the number of colonies growing on agar at 37° C. in forty-eight hours. (Public Health Reports, U.S.P.H. Service, 1914, p. 3232.)

Modern Methods of Securing Clean Milk.—1. Milking should be done in a special shed. The cowshed, if used for milking, should be washed out previously, and a sawdust bedding is better than straw. The best type of shed has two rows of cows facing one another, but separated by a central feeding passage. The stalls should be 6½–7 feet long, and the floor should slope to a channel (18 inches by 4 inches) into which all filth should fall. Each cow should have 800 cubic feet of space, and 36 square inches of permanent ventilation opening.

2. The cows should be tested every twelve months with tuberculin, and examined frequently by a qualified veterinary surgeon. It is important to remember that a cow injected with tuberculin remains insensitive to a further injection for a period of about six months. The udder and flanks of the cows should be thoroughly washed and dried before milking. At all times the animals should be kept well groomed.

3. Milkers must be healthy. Clean caps and overalls should be worn. Hands should be washed and dried prior to each milking. A hooded pail or one with a side aperture should be used, and all pails should be sterilised and kept covered prior to use. Special milking machines are frequently employed, but they are

rather complicated and difficult to sterilise. In any case the cows have to be "stripped" by hand.

4. Ordinarily the milk is filtered immediately after being drawn. If all proper precautions are taken this should be unnecessary. In any case the milk should be passed over a cooler, which is usually a corrugated apparatus through which cold water runs, and over which the milk is allowed to flow in a thin stream. It is essential that the cooler should be placed in a position where contamination from dust, etc., is unlikely. Bacteria will not multiply to any extent in a milk kept below 10° C.

5. After being cooled the milk should be filled into sterile bottles fitted with a special air-tight cap, and the whole maintained at below 10° C. till delivery.

Milk produced in this fashion is, of course, very much more expensive than the ordinary variety. A great deal can be done, however, without incurring great expense, to improve milkshed conditions and transport generally. Many of the churns in use are badly made, and filth can enter around the covers, and sufficient precautions are not taken to sterilise all milk vessels when not in actual use. Cowsheds are often filthy and milkers careless.

Trade pasteurisation is frequently carried out. In one method the milk is raised to a temperature of 60–70° C. and maintained there for a given time, usually twenty minutes. It is afterwards cooled. In the "Flash Process" the milk is raised to between 70° and 80° C. for one minute and then rapidly cooled. Either method carefully carried out destroys the majority of bacteria, but many of the toxins must escape. Dairymen are exceedingly careless with regard to the details of pasteurisation, their one aim being to delay souring of the milk. The object of pasteurisation is to protect the consumer, and if pasteurisation is practised it should be done with this intention and milk so treated should be sold as pasteurised milk.

MILK-BORNE DISEASE

1. Cows suffering from mastitis ("garget") yield a milk in which streptococci are especially common. Epidemics of sore throat are considered to have been traced to such source, *e. g.* Colchester in 1905, where some 600 cases were reported.

2. **Tuberculosis.**—Between 9% and 10% of samples of milk taken in London contain T.B. pathogenic to guinea-pigs. The same findings have been obtained in New York. In Manchester 8·7% of positive results were obtained between 1893 and 1913, tubercle bacilli being found much more commonly in the earlier samples than in the later. In Edinburgh some 20% of the samples produced tuberculosis in guinea-pigs. In the States, out of thousands of cows tested, 3·5% gave a positive reaction to tuberculin, in another and larger series 10·5% gave a positive result.

In closely populated districts where cows are stalled for a great portion of the year, the numbers infected are correspondingly high (30–37%). It is probably only in disease of the udder that tubercle bacilli are present in the milk as it is yielded by the cows, but milk may undoubtedly become contaminated with the fæces and uterine discharges of diseased animals. The Royal Commission on Tuberculosis pointed out that bovine tubercle bacilli are present in a large number of cases of disease of the alimentary tract, *e.g.* cervical glands and primary abdominal tuberculosis. In such cases "the tubercle bacillus has unquestionably been swallowed. A considerable proportion of the tuberculosis affecting children is of bovine origin—and is to be ascribed to infection transmitted to children in meals consisting largely of the milk of the cow."

Powers are granted under the Tuberculosis Order, 1913, of the Board of Agriculture (p. 288) for securing the destruction of cows suffering from tuberculosis of the udder or giving tuberculous milk, as well as of all bovine animals suffering from tuberculosis with emaciation.

In Denmark, Bang's method appears to answer satisfactorily. There, herds are tested with tuberculin, and those giving a positive reaction are separated from the healthy animals. Slaughter of all suffering from T.B. udder or T.B. with emaciation is arranged for. The infected and the healthy herds are kept apart. The calves of infected cows are fed on milk heated to 80° C. Disinfection of sheds, etc., is undertaken when necessary.

3. **Enteric Fever** (and paratyphoid fever) is frequently spread through milk supplies. In Washington 10% of all cases of typhoid during 1907–1910 were traced to milk (Rosenau). The bacilli may multiply to an enormous extent without altering in any way the taste or appearance of the milk. Infection is usually due to carriers, contacts, missed cases, etc., and is the result of lack of personal cleanliness. It may also be caused by the use of contaminated water, either for washing utensils or for the fraudulent dilution of milk.

4. **Diphtheria.**—It is thought that sores on the teats of a cow may become secondarily infected with Klebs-Lœffler bacilli (report of the Medical Officer to the L.G.B., 1913–1914 Appendix, p. 30). Infection is usually due to a carrier handling the milk at some stage.

5. **Scarlet Fever**—due to infection of some one engaged in handling the milk. It was thought at one time that a streptococcal infection of the udder and teats of the cow (Hendon disease) could produce scarlet fever in human beings, but it has always been impossible to exclude a human source in any investigation undertaken. It is possible that the organisms of scarlet fever may be superadded upon an already existing ulceration of the teats, etc., as has been proved to be possible in diphtheria.

6. **Epidemic Diarrhœa** is conveyed largely by milk which has been improperly stored or handled, and which has consequently been infected by dust, flies, etc.

7. **Cholera.**—Milk may become infected through the agency of flies, water, etc.

8. **Malta Fever.**—Fifty per cent. of the goats in Malta were found to be infected with the micrococcus melitensis, and in 10% the organisms were constantly present in the milk. After the consumption of such milk had been prohibited, the disease disappeared from the Army and Navy.

9. **Foot and Mouth Disease.**—In a few instances epidemics of sore throats and feverishness, accompanied with vesicles in the mouth, etc., have been traced to foot and mouth disease in certain milk cows.

FEATURES OF A MILK-BORNE EPIDEMIC

There is usually an explosive outburst and rapid rise to a maximum, followed by a slow decline. The infected supply may be mixed with the milk retailed by several vendors, and the cases may be spread over a wide area. Should only one dairy be infected the area will be restricted. Only those who drink raw milk will be affected at first—any persons habitually using boiled milk, or none at all, will escape. As a rule the well-to-do suffer most, children being specially affected, and females more than males. Several cases may occur in one house at the same time. Secondary cases will follow in due course. The incubation period is usually short, and the epidemic is frequently of a mild type.

ADULTERATION OF MILK

The commonest practices are the addition of water and the removal of a portion of the fat. The former may be detected by the reduction of the non-fatty solids below the standard 8·5%, and the latter by the lowering of the fat figure below the standard 3%. Separated milk is frequently added to whole milk, or skimmed milk may be mixed with fats other than butter fats, and the mixture in each case sold as whole milk. Unsweetened condensed milk is sometimes added to skimmed milk. Colouring matter, principally annatto, is often used to produce the artificial yellow appearance which the public apparently desire. Sodium carbonate has been occasionally added to conceal partial souring. No preservative may be added to milk, *vide* P.H. (Milk and Cream) Regulations, 1912 (p. 278). Under the same regulations no preservatives may be added to cream containing less than 35% by weight of milk fat. To cream containing more than 35% of milk fat 0·1% peroxide of hydrogen or 0·4% boric acid (1917

Amendment Order) may be added. No thickening substance may be added in any case.

PRESERVATION OF MILK

1. Boiling, if prolonged, completely sterilises. Milk just raised to the boiling-point is not sterilised. Pasteurisation and refrigeration have already been referred to.

2. **The Budde Process** for preserving milk or cream consists in the addition of about 15 c.c. of a 3% solution of H_2O_2 per litre of milk, and subsequent heating of the whole at 52° C. for three hours. The peroxide of hydrogen is decomposed by the ferment catalase and all bacteria are said to be destroyed. If such milk or cream is bottled immediately, it should remain sweet for at least a week, even in warm weather.

3. Milk may be sterilised by electricity. Experimental work has been carried out in Liverpool, and it was found possible to destroy over 99% of the total organisms. The method is somewhat complicated and rather expensive.

4. **Dried Milk.**—Two methods of manufacture are employed—

(*a*) Milk is sprayed on the surfaces of two metal cylinders placed side by side at a distance of not more than 2 mm. The cylinders are heated by steam to a temperature of about 140° C. and rotate in opposite directions. The milk collects in the gap between the cylinders and is carried round in a dry film on the surface till it comes in contact with two knife-edges which scrape off the pellicle. The flakes of dried milk are then pounded and packed in tins.

(*b*) The milk is strained and then warmed and separated if so desired. It is next pasteurised at a temperature of from 70°–75° C. and concentrated in a vacuum pan at 58° C. to less than half its original bulk. When sufficiently concentrated it is heated to 95° C. and immediately cooled to 58° C. again. From the pan it passes to a pump which forces it, under a pressure of from 2000–3000 lbs., as a fine spray into a tin-lined chamber to which a current of hot air at 115° C. is also admitted. The milk droplets are dried at once and fall on the floor. The dried milk is collected, sifted, and packed.

If packed in air-tight tins, dried milk keeps excellently. It is portable and does not suffer in transit. As a result it is used largely on board ship and in the tropics. There is little waste, as only what is required at the moment need be made up. Bacteria are not all killed in the process, but their numbers are reduced. Probably many organisms are introduced during the stages of powdering and packing. Tubercle bacilli may survive and be capable of infecting guinea-pigs, but their virulence is much diminished. Dried milk represents a concentration seven or eight times that of the milk from which it was prepared.

The following figures show the average composition—

Fat	25–28%
Protein	25–28%
Sugar.	34–40%
Ash	6–7%
Water	5–7%

Little adulteration is practised, but cane sugar, bicarbonate of soda, phosphates, boric acid, and salicylic acid have been known to be added. No preservative is allowed under the P.H. (Milk and Cream) Regulations, 1912.

5. **Condensed Milk**—Three varieties are common—

(*a*) Whole milk unsweetened.
(*b*) Whole milk sweetened.
(*c*) Skimmed milk sweetened.

Typical percentage figures for the three varieties are—

	Total Solids.	Fat.	Lactose.	Proteins.	Cane Sugar.
(*a*) . .	38	12·4	16	8·3	—
(*b*) . .	77·2	13·7	15	9·7	37·2
(*c*) . .	67·6	0·3	16·6	12·3	35·8

The concentration is roughly three times.

Process of Manufacture.—Fresh milk, after being strained, is pasteurised at 80°–85° C. Cane sugar, 14–15%, is added, and the mixture run into copper vacuum pans. These pans hold from 1000–3000 gallons and are heated by means of steam pipes at the bottom. The tops are connected with an exhaust. Milk is thus boiled under reduced pressure at a temperature of about 50° C. for from two to three hours. When the milk mixture has reached the proper consistency it is drawn off into metal cylindrical coolers, which rotate slowly in tanks of cold water for another two to three hours. The condensed milk is finally filled into tins which are clean but not sterilised.

Such milk is not really sterile. Staphylococci, streptococci, B. subtilis and various ærobic and anærobic organisms have been found. From 130–2000, or more, organisms may be grown on agar from 1 gram of the milk. B. coli is usually absent, however, and no pathogenic organisms have been detected. Tubercle bacilli, added artificially, were destroyed in the process. Condensed milk usually keeps well, but tins not infrequently " blow," due to the presence of a yeast. In the tropics, sweetened condensed milk occasionally assumes a thicker consistency and develops a brown colour. This was considered by Beveridge to be caused by spore-bearing bacilli. Preservatives are rarely found, and none is permitted by the P.H. (Milk and Cream) Regulations, 1912. In some large imported tins a mixture of boric acid and borax has been detected. Condensed milk must be properly labelled when sold. This is especially important in

the case of the skimmed variety, which should on no account be used for infant-feeding.

While there are no standards for condensed milk, it was proposed by the Departmental Committee in 1901 that a genuine sample should contain at least 10% butter fat, and that no preservatives or foreign matter other than sugar should be added (L.G.B. Report, New Series, No. 116, 1918).

OTHER PREPARATIONS

Homogenised Milk.—Milk is forced under considerable pressure against agate knife-edges. By this means the fat globules are greatly reduced in size and will not rise to the surface as cream on standing.

Koumiss is the partially fermented milk of the mare or ass. It is now made artificially from cows' milk by the addition of sugar and yeast.

Kefir is much the same as Koumiss, and is used in the Caucasus. Fermentation is produced by the addition of special fermenting material.

Youghourt is the curdled milk of the buffalo, goat, ewe, or cow. It is used in Turkey.

Synthetic Milk is an artificial substance made mainly from soya beans.

INFANT FEEDING

When artificial feeding is necessary, cows' milk in one or other form is the best substitute for human. In most cases it is advisable to pasteurise all such milk. This is best done at home by using a special vessel containing a carrier. In this the bottle holding the feed is immersed in water up to its neck and maintained at a temperature of 60° C. for half an hour. At the end of this time the carrier containing the bottle is removed and plunged into cold water. The bottle is closed either by a teat or by a plug of wool.

Boiled milk is thought by many to be the cause of scurvy-rickets in infants, but Lane-Claypon (Report to the L.G.B., New Series, No. 63, 1912) found that the balance of evidence, clinical and experimental, shows—

1. That there is apparently no loss of nutritive value in feeding an animal on boiled milk of the same species.

2. That, if anything, boiled milk of another species is more nutritive than unboiled.

Most workers, however, consider it advisable to supplement boiled milk with such antiscorbutics as orange juice, etc. It is unnecessary here to enter into details of dilution of milk for infant feeding. Each child is a problem in itself, and no hard and fast rules can be laid down for any group of children.

Humanised Milk.—By dilution and adjustment, cows' milk

may be made to resemble human milk as regards its content of fat, lactose, protein, etc. One of the best-known varieties is the whey-cream mixture. To prepare this, stand one pint of milk for three hours and then skim off the cream. Divide the skimmed milk into two equal parts, and to one add a little rennet. Strain off the resultant curds and heat the whey to 150° F. to prevent further action of the rennet. Mix the whey, the remaining half of the skimmed milk, and all the cream together. Add 3 drachms of lactose and pasteurise the whole. By this means a portion of the more indigestible caseinogen is removed and the lactalbumin remains unaltered.

Dried Milk is becoming increasingly popular in infant feeding, and many of the baby clinics throughout the country supply it to mothers at cost price. It is the safest of all preparations of cows' milk, and is especially useful during periods of epidemic diarrhœa. It has not been shown to cause scurvy or rickets, but it is well to give some fruit juice along with it. The cost compares favourably with that of most patent infant foods. In addition the clot formed with dried milk is softer than that of ordinary cows' milk.

Condensed Milk.—Skimmed condensed milk must never be used, and should really be labelled as unfit for infant food. Sweetened and unsweetened full milk sometimes answer well when fresh-milk mixtures disagree and cause sickness, or when the change from breast- to bottle-feeding is taking place. Such condensed milks are said not to clot with rennet, or, if they do, the clot is much looser than is the case with ordinary cows' milk. Under any circumstances these milks should be used only for short periods, when some special reason for their adoption arises. Once a tin is opened it should never be kept for long.

Proprietary Foods have been divided into the following groups (Report to the L.G.B., New Series, No. 80, 1914)—

1. Foods with a basis of dried cows' milk, but mixed with flour.
2. Foods consisting mainly of flours, mixed with a proportion of malt flour and malt extract, but containing much unaltered starch, which is not converted during the process of preparing the food for infants in accordance with the directions given on the package.
3. Foods consisting mainly of starch, either unaltered, or altered only by heating.
4. Foods containing flours, but also containing active diastase or pancreatic ferment, so that, if the food is carefully prepared according to the direction on the package, the starch is appreciably altered.
5. Foods manufactured from flours, the starch of which has been mainly or partially converted into soluble products during manufacture.

The Report concludes that many proprietary foods are unsuitable for infants under seven or eight months, and may cause serious injury. The evil results may be due to, (*a*) presence of starch in greater or less amount, (*b*) presence of excess of carbohydrates—starch or sugar—with relation to the protein and fats, (*c*) deficiency in fat. Poor people are misled by extravagant statements on the packages, and it might be advisable to require all infant foods containing more than 25% of starch to be labelled as unsuitable for infants under seven or nine months, except on the advice of a medical man.

Success does not always attend proceedings taken under the Sale of Food and Drugs Act, even when the analytical findings and the claims made in the advertisements are at total variance.

Milk Depots.—Authority to establish these is given under the Milk and Dairies (Consolidation) Act, 1915.[1] Any S.A. may establish and maintain depots for the sale, at not less than cost price, of milk specially prepared for consumption by infants under two years of age. Such depots were first established in England in 1899. The practice was to obtain as pure milk as possible and to modify it to suit infants of different ages. One feed was put in each bottle and the whole was sterilised and cooled. Each mother got bottles corresponding with the number of feeds prescribed. Such a method is very costly. Dried milk is now used in certain depots and given out to the mothers in quantities sufficient to last for a week at a time. No depot should be conducted without the advice and supervision of a Medical Officer, otherwise artificial feeding is liable to be substituted in cases where the change is altogether uncalled for.

The reader is referred to Lane-Claypon's *Milk and its Hygienic Relations*, 1916, Savage's *Milk and the Public Health*, 1912, and the various L.G.B. reports quoted for more detailed information on the subject of milk.

BUTTER

Average analysis—

Fat	83·5%
Casein	1·0%
Ash	1·5%
Lactose	1·0%
Water	13·0%

A limit of 16% of moisture is fixed by the Butter Regulations, 1902, and the Margarine Act, 1907. The latter Act also lays down a limit of 24% of moisture in "milk-blended" butter.

Salt is usually added in amounts varying from 0·5–6%. It is said to prevent decomposition of the casein.

Process of Manufacture.—Either milk or separated cream is churned and the fat globules made to coalesce into a solid mass.

[1] See p. 286.

Churning should be continued at a comparatively low temperature for about thirty minutes. The butter is subsequently well washed and beaten to remove as much curd and butter-milk as possible. This aids keeping. Cream is usually allowed to stand for some hours before being churned to allow of bacterial growth. The organisms producing this "ripening" of the cream have been isolated in pure culture, and are now used frequently as "starters" in dairies where pasteurised cream is used for butter-making.

Butter fat is a mixture of the glycerides of various volatile fatty acids, especially butyric, palmitic and oleic. The percentage of soluble volatile fatty acids, of which butyric acid is the chief, make butter fat quite distinct from the majority of other fats, animal or vegetable, and on their presence depends the chief test (Reichert-Wollny) for distinguishing butter from margarine.

Adulteration.—The two commonest adulterations are the admixture of other fats and the presence of excessive amounts of moisture. Artificial colouring matter is often added—principally annatto. It must not be forgotten that butter made from the milk of Jersey cows often has an almost artificial yellow colour. Preservatives—especially a mixture of borax and boric acid—are frequently added, but this constitutes no legal offence. The Departmental Committee on Preservatives and Colouring Matter recommended that not more than 0·5% of this mixture (as boric acid) should be allowed. Benzoic acid, salicylic acid and fluorides have also been detected.

Tubercle Bacilli.—Butter made from fresh cream contains relatively more bacteria than does milk, as the bacteria tend to rise to the surface with the cream. Butter made from tuberculous milk has been proved on many occasions to contain tubercle bacilli. On this account many are in favour of pasteurising cream before churning. A temperature of 60° C. for twenty minutes will kill all pathogenic organisms and will not seriously interfere with the manufacture of the cream into butter. Cold storage does not destroy tubercle bacilli in butter.

Margarine is made from refined animal and vegetable fats with the addition of milk to give the whole a flavour of butter. Beef and mutton fat are largely used, and of late years vegetable oils, such as coconut, cotton-seed and sesamé, have been more and more employed. Such oils contain only a trace of soluble volatile fatty acids, and consist mainly of the glycerides of oleic, stearic and palmitic acids.

The Butter and Margarine Act fixed the limit of moisture at 16% and prohibits a greater amount of butter fat than 10%. For the various legal provisions regarding margarine see p. 282.

Margarine forms a wholesome food, but is of considerably less value than butter, in that it is deficient in fat-soluble accessory substance or anti-rachitic vitamine.

Milk-blended butter is usually imported butter into which an

additional amount of milk has been worked in this country. The Margarine Act of 1907 lays down a limit of 24% of moisture. It is a sort of substitute for margarine.

CHEESE is made from whole milk, whole milk and cream, or skimmed milk. The caseinogen is coagulated by rennet, and the mass pressed. Some months usually elapse before the cheese ripens.

Typical analyses are (after Moor and Partridge)—

	Water. %	Ash. %	Fat. %	Casein. %
Cheddar	33	4·3	29·5	27·4
Cheshire	37·8	4·2	31·3	25·7
Gloucester	37·4	4·6	28·1	28·3
Stilton	21·2	2·9	45·5	26·3
Cream	57·6	3·4	39·3	19
American	30·6	3·6	27·7	30·8
Dutch	41·8	6·3	10·6	32·5

Most typical English cheeses are made from whole milk, but Stilton may be made from milk and cream. Cream cheese may contain as little as 6% or as much as 40% of fat. There are no legal standards. In Gorgonzola, moulds are added artificially, and a coating of barium sulphate is usually applied to the cheese, forming at times as much as 20% of the total weight. Roquefort is made from ewes' milk, and Dutch cheese from skimmed milk. Margarine-cheese is a mixture usually of skimmed milk and refined animal and vegetable fats. It must not be sold as "cheese."

Adulteration is rare. The cheese mite (acarus domesticus) is commonly found and maggots are occasionally present. Blue mould is due to aspergillus glaucus and red mould to sporendonema casei. Salts of arsenic, copper or lead have at times been smeared over the surface of cheese as preservatives.

Tubercle bacilli have been found in a considerable percentage of cottage cheeses examined. They may remain virulent for seventy days and, as many cheeses may be consumed within this period, the risk is apparent. As in butter, this fact has been adduced as an argument in favour of making cheeses from pasteurised milk. The addition of 0·25% of HCl to pasteurised milk facilitates clotting, and is said to produce excellent results.

Tyrotoxicon is a poison which may develop by bacterial action in cheese and produce gastro-intestinal and nervous symptoms. A small outbreak was reported by Newman in Finsbury in 1901. The symptoms did not last long and there were no deaths. A more severe outbreak occurred at Aldershot in 1899, the prominent features being fever, hæmatemesis and jaundice. Several of the cases died.

EGGS weigh on an average 2 ozs., the yoke forming about 30%

and the white 60% The yoke, which is mainly fat, contains lecithin and some nucleo-protein. The white consists of albumin and water.

Analysis—

	%
Protein	12·55
Fat	12·11
Salts	1·12
Water	73·67

Fresh eggs should sink in water or 10% salt solution, and are translucent.

Dried eggs and liquid eggs are used extensively. The latter usually contain a good deal of boric acid as a preservative.

Egg powders are really nothing but baking powders coloured yellow. Lead chromate has been found in such, and arsenic, derived from impure phosphate, has been detected.

MEAT

Inspection of Live Animals.—Signs of illness: Hanging head, dull eyes, roughened coat, occasional shivers, loss of appetite, hot muzzle, nasal discharge, cough, rapid breathing, watery dung with blood or mucus, blown abdomen, œdema, etc. Rectal temperature is normally about 101·5° F. and pulse rate 40.

Special Diseases. *Anthrax.*—General sickness, blood in stools and urine, rapid pulse and high temperature. A more chronic form may be observed, with recovery in certain instances. The diagnosis is made by discovery of anthrax bacilli in blood taken from the ear.

Foot and Mouth Disease.—Vesicles, ultimately breaking down into sores, about the udder, mouth and feet. Nasal discharge, stringy saliva, feverishness.

Tuberculosis.—Cows are specially affected. Pigs suffer frequently, sheep and goats very rarely. The main signs are cough, rapid breathing, hard nodules in the udder, and emaciation. Diagnosis is settled by a positive tuberculin reaction. The temperature of the animal should be taken several times during the day, and tuberculin (30–50 minims, Koch's old tuberculin) injected the same evening. The temperature of the animal is taken every two hours from the tenth to the twentieth hour after the injection. A rise of 2° F. above the normal, if gradual and distributed over a period of several hours with gradual decline, indicates a positive reaction. Animals that have, just before, undergone any marked change in their mode of living may fail to react, so too with cows in heat, or bovines suffering from advanced disease, or those that have been injected within the previous month or two.

Pleuro-pneumonia.—General illness with dyspnœa, tenderness on pressure over the ribs, and signs of pneumonia.

Other diseases are actinomycosis, garget or inflammation of the udder, dysentery, jaundice, cow pox, etc.

In addition, sheep may suffer from braxy, louping-ill, rot, scab, etc.

SLAUGHTER OF ANIMALS.—Slaughter of bovine animals is usually performed by pole-axing, or shooting by means of a special short-barrelled apparatus. The animal may be pithed subsequently in the former case, and should at any rate be bled by cutting the neck vessels. The Jewish method of slaughter consists in cutting the throat without first stunning the animal. Pigs, sheep, and calves are generally slaughtered in this manner.

At present, on account of the enormous numbers of private slaughter-houses, it is impossible to carry out satisfactory inspection. The principal objections to private slaughter-houses are—

1. Unsuitability of construction and difficulty in cleaning.
2. Close proximity to dwellings.
3. Retention of animals in lairs close to houses, with frequent awkward means of access.
4. Nuisance from bad storage of offal, and, at times, discharge of offal and blood into sewers.
5. Lack of proper storage for meat.
6. Impossibility of adequate inspection.

On the other hand, the butcher states that conveyance of meat from abattoirs causes it to lose its appearance, that the price of meat would be raised and rates increased if public abattoirs were to be built.

The advantages of public slaughter-houses, however, are so obvious that it is necessary only to enumerate the main points—

1. Animals would be spared much suffering.
2. Nuisances would be removed from the neighbourhood of dwelling-houses, meat would be systematically inspected and waste products could be dealt with on the spot.
3. Properly conducted premises can be made to pay their way.
4. The public would prefer to buy meat that had been officially examined. Meat, if conveyed in proper hanging-carts, does not suffer in appearance.

Local authorities have, however, no power to close private slaughter-houses, and the expense of purchasing suitable sites in populous districts is one of the main arguments against action being taken.

Requirements of a Good Abattoir

Site.—On the outskirts of the town, but not too far from retail shops. If possible a railway should adjoin. There should be a

good water supply, and means of disposal of sewage. The site should allow for the possibility of future extension.

Buildings Necessary.—Lairs, buildings for slaughter of animals and hanging of carcases, cold storage, condemned meat room, destructor, manure dump, boiler-house, dressing-rooms and lavatories, offices, etc.

It is advisable to have a special place for the slaughter of diseased animals, and arrangements may be made for the handling of hides, making of tripe, gut scraping, fat melting, etc.

For the Memorandum and Byelaws regarding slaughter-houses see p. 267.

MEAT INSPECTION.—Carcases should be inspected as soon after slaughter as possible. In any case the viscera should always be retained for examination.

How to proceed—

Head.—Examine the jaw for actinomycocis ("lumpy jaw"), the mouth, etc., for foot and mouth disease, and the glands (submaxillary, retropharyngeal and parotid) for tubercle, etc.

Tongue.—Palpate for actinomycosis ("wooden tongue").

Lungs.—Palpate, and cut into, for tubercle, parasitic cysts, pneumonia, etc. Examine the bronchial glands.

Liver.—Palpate and incise. Inspect for tubercle, abscesses, necrosis, flukes, etc. Examine portal glands.

Stomach, especially the external coat and the gastric glands (tubercle).

Spleen.—Palpate and incise for anthrax and tuberculosis.

Mesentery.—Examine glands.

Udder.—Palpate and incise for tubercle, etc.

Carcase.—Cows show evidence of an udder; bulls have specially heavy bones, coarse dark flesh, not much scrotal fat (or fat generally) and a large erector muscle and penis; oxen have more fat generally than bulls, and the scrotal fat ("cod") is plentiful; their general development is slighter.

Note any emaciation, hæmorrhages, œdema, emphysema, jaundice, etc., and examine the parietal pleura and peritoneum carefully for tubercle, pleurisy, etc. The pleura and peritoneum should never be removed ("stripped"). Rigor mortis sets in about twelve hours after slaughter if the animal was healthy. The meat itself should be light red in colour, firm, not too moist to the touch, and marbled with fat. There should be no unpleasant odour. Drugs administered shortly before death may taint a whole carcase. Decomposition is detected by alterations in appearance, smell, and consistence. It is often advisable to plunge a skewer into the flesh in the neighbourhood of bone. Any unpleasant smell will indicate putrefaction, especially in refrigerated meat or hams. Fat amounts to some 15%, and bone to some 20%.

Veal.—"Slink veal" is the flesh of newly-born or still-born

calves. It is pale, watery and gelatinous. Lungs are collapsed. It is unfit for human food.

Horse Flesh is dark and coarse, with a rather sickly odour, soapy feel and yellow fat. The horse has eighteen pairs of ribs (ox, thirteen) and the bones generally are larger. Occasionally the fat and bones are removed from the flesh, and beef fat substituted. Horse flesh contains more glycogen than ox flesh. This may be tested by treating a decoction with a few drops of iodine potassium iodide solution, when a violet coloration is produced. The horse's liver has three lobes (ox, four) and no gall-bladder. The kidney is not lobulated. There is no bone in the inter-auricular septum of the horse's heart, as there is in the ox's. The horse's tongue is rounded and the ox's pointed.

Unsound Meat.—Apart from decomposition, emaciation, immaturity, death from drowning, etc., carcases may be unfit for food on account of definite disease processes. The chief of these are—

Tuberculosis (differentiate actinomycosis, cysticercal and echinococcal cysts in organs, pyæmic abscesses in liver, lungs, kidney and spleen). The diagnosis of tuberculosis is confirmed generally by the characteristic naked-eye appearance of the adjacent lymphatic glands. The lungs and pleuræ are affected in from 30–40% of all cases, the pleuræ and peritoneum in 15–20%. The serous membranes should never be stripped. Such a practice is sufficient to condemn a carcase. Disease in the udder affects usually one quarter only, and as a rule no abscess formation follows. Care must be taken in cutting up tuberculous organs, etc., not to smear infected material over sound organs or flesh. A knife used for incising a tuberculous focus should at once be discarded. The same rule should apply to any cloths used for wiping such carcases. In generalised tubercle with foci in the meat, the popliteal, precrural, inguinal, pubic (male) or supramammary (female), iliac, lumbar and prescapular glands will show signs of disease. A good deal of practice is required before an inspector can cut down on these glands with any degree of accuracy.

The Royal Commission on Tuberculosis made the following recommendations with regard to condemnation of the whole or part of a carcase infected with tubercle—

Condemnation of the whole carcase and organs—

(*a*) Miliary tubercle of both lungs.
(*b*) Tubercle of both pleura and peritoneum.
(*c*) Tuberculous lesions in the muscles or glands between the muscles.
(*d*) Tubercle with emaciation.

Condemnation only of the affected parts—

(*a*) Lesions confined to the lungs and thoracic glands.
(*b*) Liver only affected.

(*c*) Pharyngeal glands only affected.

(*d*) Any combination of the foregoing, relatively small in extent.

All foreign meat where the pleuræ have been stripped should be condemned, as should also the carcases of pigs infected in any degree with tubercle;[1] sheep and goats are very rarely attacked.

In Germany the system of "Freibank" was in operation. The tuberculous meat was either stamped as inferior and sold as such to the public, or efficiently sterilised by heat prior to sale if the disease was more extensive. Considerable saving was effected in this way.

Actinomycosis affects either the jaws ("lumpy jaw"), where the condition may ultimately go on to suppuration, or the tongue, where ulcers or nodules (internal or external) may be produced. Occasionally the lungs show deposits and rarely the condition may become generalised. In the majority of cases it is sufficient to condemn only the affected parts.

Anthrax.—The spleen becomes much enlarged and very soft, the blood is dark. The whole carcase should be condemned.

Pyæmia.—In acute condition with recent abscess formation and general signs of cloudy swelling, etc., in organs, the whole carcase should be condemned. In old-standing cases with localised abscesses only the parts affected should be seized.

Septicæmia.—This group includes acute diseases with symptoms referable to the intestines, uterus, udder, etc. Such conditions have produced serious outbreaks of food poisoning in human beings, and on no account should the meat be passed for human consumption.

Uræmia, general œdema, marked jaundice all suffice to condemn the whole carcase; so too with pleuro-pneumonia, advanced foot and mouth disease, swine fever.

Parasites.—(For life-histories, etc., see p. 210.)

Beef "measles" (cysticercal or larval stage of tænia saginata) may be recognised as small, grey, transparent-looking cysts, ranging in size from a pin's head to a pea. The parts most frequently affected are the muscles of the head, neck, and shoulders, the heart and occasionally also the various organs. **Pig "measles"** (cysticercus cellulosæ of tænia solium) show much the same picture, but are rather more transparent, and are not found so frequently in the heart muscle. The cysticerci in either case may show caseous or calcareous degeneration. In the latter case a gritty sensation is noted on cutting. Such flesh is unfit for food, and the carcase should be condemned.

Trichina Spiralis.—The encysted larval stage is found in the muscles of the pig, especially the diaphragm, the muscles of the tongue and throat, and the intercostals and abdominal muscles. They appear as tiny white specks scattered over the cut surface

[1] If tubercle is found only in the glands about the head, the usual practice is to seize the head only.

of the flesh. Samples of flesh may be taken from the muscles most frequently implicated, carefully pressed between two glass slides and examined microscopically. A little acetic acid may be added to dissolve any calcareous deposit around the cysts. "Rainey's capsules" may be mistaken for trichinosis. They are cylindrical in shape, surrounded by a thick capsule and filled with oval corpuscles. They lie actually in the muscle substance and not between the fibres. No harm results from their consumption. Carcases affected with trichinæ should be condemned.

Other parasites whose presence does not necessitate condemnation of the whole carcase are—

Hydatid cysts, found most frequently in the liver and lungs of sheep, and more rarely in the kidneys, spleen, heart, peritoneum, etc. In the liver the cysts may undergo caseous degeneration, and the condition is apt to be mistaken for tuberculosis. **Cysticercus tenuicollis,** the larval stage of tænia marginata of the dog, is found most frequently in sheep, especially in the serous membranes. The invaginated head has a long, slender neck, hence the name. **Flukes** produce the condition known as "pipey" liver. The ducts show fibrous proliferation and stand out on the surface of the organ. On section of the liver the flukes may be pressed out of the affected ducts. Only the organs concerned need be condemned. **Strongylus rufescens** is found in the lungs of sheep. The embryo becomes encapsulated, and an appearance not unlike tubercle is produced. In fact the term pseudo-tuberculosis has been applied to the condition.

Onchocerciasis (L.G.B. report, New Series, No. 45, 1911) is a nodular condition found especially in the brisket, flank and forequarter of Australian beef. Less commonly the knee region of the hindquarter and the muscles generally may be affected. The names of "worm kernels, nodules or nests" are given to the condition by butchers. The parasites are round worms (male $1\frac{1}{2}$ inches long, length of female unknown) belonging to the genus onchocerca (sub-group of the filariidæ), and require to be taken up by a biting insect and to undergo development therein before they can be transmitted to another warm-blooded animal. The exact life-history is not known, but the intermediate host is probably a stomoxys, hippobosca, tabanid, etc. The nodules contain the adults and the embryos, and, on section, show small loops of female worm like pieces of catgut. The fibrous tissue is due to some toxic excretion by the worm. The parasites survive only a few hours the death of the cattle, and man cannot be infected as a result of eating such meat. The condition is considered, however, to render meat unfit for human consumption.

Sausages contain a mixture of minced meat and bread-crumbs or meal, the relative proportions varying greatly. They are usually well spiced and preserved with boric acid. Sulphites are sometimes added as a preservative. Frequently the ingredients

are of doubtful quality in the first instance, and the addition of a preservative tends to conceal this from the purchaser. Horse flesh has been used occasionally, and may be detected by the glycogen test. Only sound, well-cleaned intestines should be used as sausage skins. Early putrefaction can be detected by boiling portions of the sausage in lime water, when a very unpleasant smell will result. In 1908, MacFadden suggested a limit of 0·25% of boric acid in sausages (L.G.B. Food Report, No. 6, 1908).

Meat Extracts are made by boiling meat under pressure and evaporating the resultant extract in vacuo. They contain very little protein and consist mainly of extractives and salts. Occasionally a little meat fibre may be added in an endeavour to raise the protein value of the extract.

Meat juices are manufactured without heating, and contain more protein than do extracts.

Typical analyses are—

	Water.	Protein.	Extractives.	Mineral matter.
Meat extract . .	18%	9%	30%	24%
Meat juice . .	59%	16%	16%	9%

FISH

The signs of decomposition are—flesh soft and separating readily from the skin and bone, eyes sunken, gills discoloured, unpleasant smell. Gills have been known to be coloured artificially and eyes to be "doctored" to prevent their sinking inwards. Decomposing fish, especially mackerel, is liable to cause gastric disturbance, and the tape-worm di-bothriocephalus latus is conveyed to man through eating infected fish (very rare in this country, *vide* p. 212).

Shell Fish, especially oysters, are liable to be kept in "layings" contaminated by sewage, etc., from adjacent towns. The storage of shell fish in shops is frequently very unsatisfactory, and dead or dying oysters may be retailed. Some persons show a definite idiosyncracy with regard to shell fish generally—urticaria and gastro-intestinal symptoms invariably following their consumption. Mussels are alleged to contain at times an alkaloid "mytilotoxin" in their livers, and several serious outbreaks of poisoning have been attributed to eating mussels affected in this way—Wilhelmshaven, 1885, and Dublin, 1890 (see under Food Poisoning). The most common disease, however, conveyed by shell fish is enteric fever, and numerous instances have occurred, notably in Southampton and Winchester in 1902. Cholera too has been attributed to the consumption of infected shell fish. Oysters taken from unpolluted sea water contain no B. coli or

B. enteritidis sporogenes (indicators of sewage contamination), while oysters from doubtful sources contain large numbers. The proportion of such organisms appears to be relatively greater in the shell fish than in the sea water in which they live. B. typhosus is said to retain its vitality in sea water for four weeks, and V. choleræ for two weeks; both organisms may survive in oysters for seventeen or eighteen days. Oysters, however, taken from contaminated layings and removed to pure water cleanse themselves in from two to three weeks.

Legislation enabling Sanitary Authorities to deal with infected layings had been urged for years, and resulted in the P.H. (Shell Fish) Regulations, 1915. These were made under the P.H. (Regulations as to Food) Act, 1907. A Sanitary Authority has now power to deal with layings if the fish have caused disease or are likely to be a danger to health. The M.O.H. reports any suspected layings to his S.A., who may, by notice, require fishmongers to send returns to the M.O.H. of all layings from which shell fish have been obtained during the six weeks prior to the date of notice. Provision is made to enable S.A.'s to deal with layings outside their own districts. Within their own districts S.A.'s may prohibit the sale of shell fish till placed in fresh layings for a given period. S.A.'s must report any action taken to the L.G.B. and the Board of Agriculture and Fisheries, and there is appeal to the L.G.B. in cases of dispute.

FOOD POISONING.—Food may be injurious to human beings in various ways—

1. Certain articles are toxic in themselves, *e.g.* poisonous fungi eaten in mistake for mushrooms.
2. Chemical contamination, *e.g.* metals in tinning processes, arsenic from harmful colouring matters, preservatives injudiciously employed.
3. Parasitic infections.
4. Bacterial infection—much the most important group.

Food Poisoning of Bacterial Origin.—(Savage's Report to the L.G.B., New Series, No. 77, 1913.)

Since 1878 there have been recorded 79 outbreaks in Great Britain and Ireland, of these 66 were due to flesh food, 6 to ice-cream, 3 to milk, 1 to cream, 1 to pine-apple jelly, and 1 to potatoes (probably).

Of the flesh food—

35% were due to fresh (not made up) meat.
20% ,, ,, ,, tinned meat.
45% ,, ,, ,, specially prepared meats.
38% ,, ,, ,, brawn or meat pies.

Pig flesh caused most outbreaks, cattle flesh came next, while fish was responsible for six.

Clinical Course.—*Incubation Period*—half to thirty hours, usually six to twelve hours. It varies even in individual epidemics, the variation being due to the fact that toxins either may be actually ingested in the food, or may be developed only after the food has been eaten. Usually both conditions co-exist.

Symptoms, etc.— Sudden onset, usually with vomiting, diarrhœa, and abdominal pain. Cold sweats, rigors, and collapse may follow, with prostration lasting long into convalescence. Headache, giddiness, numbness and cramps in the limbs, herpes and urticaria may occur. There is usually diminution of severity after two to three days, but a course not unlike that of typhoid fever may be followed. There is no age or sex predisposition. It is rare for an individual to become infected from an actual case, but such has been recorded. The infectivity rate is usually high. As many as 80–100% of those eating the infected food may fall ill. Prevalence is greatest in the hot months—especially August. The case mortality may be nil. Out of 3098 cases there were 67 deaths—2·16%. In true Gærtner infections the rate was 2·7% (from none to 17%). Pathological appearances include swelling, congestion, and minute hæmorrhagic erosions of the mucosa of stomach and intestines, with congestion of liver, spleen, and kidneys. Usually there was nothing abnormal noticeable in the affected food, but slightly unpleasant taste and smell have been recorded. Turbidity of the gelatine may be found in such foods as brawn. There may also be undue moisture.

Bacterial Findings.—(*a*) Gærtner group, 71% of all outbreaks.

(*b*) Proteus and Coli group. Savage points out that putrefaction is not a cause of widespread outbreaks, but occasionally meat in a stage of early decomposition may cause symptoms. "While the conception that the symptoms are due to ptomaines must be abandoned, it is probable that other toxic substances are produced which, on ingestion with the food, are liable to cause gastro-intestinal disturbances which may be of considerable severity."

(*c*) B. botulinus is a rare cause of food poisoning. It is a sporing anærobe and produces powerful toxins, which reproduce the symptoms when injected into, or fed to, animals. The toxins are destroyed by heating for half an hour at 80° C. Light and air are also inimical. The spores themselves are not highly resistant. The symptoms are mainly nervous, and arise in twenty-four to thirty-six hours—paralysis of accommodation, ptosis, diplopia, aphonia, dysphagia, dryness of the mouth and throat, and retention of urine. There is no fever or loss of consciousness. Gastro-intestinal symptoms are absent or slight. Death, due to bulbar paralysis, occurs in 25–30% of cases. The foods affected are usually liver and blood sausages, pickled and smoked meat, tinned meat, etc. Such foods are often eaten

raw. The B. botulinus enters the food from outside sources, and thrives under anærobic conditions, *e. g.* in ham stored in brine. Efficient cooking is protective.

The Gærtner Group includes B. enteritidis, B. paratyphosus B., B. suipestifer or B. Aertrycke, bacilli causing septicæmia and pyæmia in cattle, etc., and B. typhi murium and Danysz's bacillus, as used in rat viruses.

It is possible that the rat harbours the B. enteritidis in its intestine, and infects cattle, etc., through contaminated food. Apparently the organism is not a normal inhabitant of the bowel either of man or cattle.

The bacilli are killed in thirty minutes at 60° C., the toxins, however, resist 100° C. for thirty minutes. Ordinary cooking frequently fails to sterilise the centre of large pieces of meat. Meat may be infected either as a result of a disease process in the animal prior to slaughter, or to contamination subsequent to slaughter, *e. g.* by excreta. In all probability the bacilli are derived either from animals actually suffering from disease or from animal carriers.

Special Food Poisoning.—Mussels (mytilotoxin), cheese (tyrotoxicon), potatoes (solanin), and ice-cream; symptoms are most likely due to toxins elaborated by various bacteria. A pathogenic strain of B. coli or B. lactis ærogenes has been isolated from cheese. Peeled potatoes form an excellent medium for bacterial growth.

Preventive Measures include skilled meat inspection at the time of slaughter, separation of slaughter-houses from places where food is prepared, thorough cleanliness of premises and reporting of all cases to the M.O.H. It is possible that rat viruses are too easily purchased, as illness in man has been traced to their use.

In 1911 the L.G.B. issued a memorandum on the investigation of outbreaks of suspected food poisoning. It advises the M.O.H. to report all cases to the Board, and to investigate at once the methods of preparation of suspected foods. Samples of suspected food remaining over and similar articles, *e. g.* unopened tins, should be collected for bacteriological and chemical analyses, due care being taken to forward such samples packed in ice. Specimens of blood from patients and suspected carriers should be examined and any post-mortem material of value reported upon. Included in the memorandum is a comprehensive list of headings of inquiry.

VEGETABLE FOODS

Wheat and Wheat Flour.—(L.G.B. Food Report, No. 55, 1911.) The wheat berry consists of pericarp and testa (15%), endosperm or parenchymatous cells (80%), aleurone layer rich in protein and free from starch (3–4%), and germ or embryo (1·5–2%).

Wheat may be ground either by the older stone mills or by roller

mills. In the former case, an upper millstone revolves upon a lower stationary one, and the resulting products are sifted through sieves with a mesh of 70–100 to the linear inch. This method is possible with home-grown wheats, but many foreign wheats have such a brittle skin that the flour would be full of small particles of bran.

In the process of roller-milling the wheat is first cleaned and washed to remove any dirt and to soften the outer husk. It is next passed through two pairs of fluted iron "break rollers," run in the same direction, but at differential speed. The crushed product from each pair of rollers is sifted before entering the next. The finest siftings are known as "break flour," and the residue is graded into coarse and fine semolina and coarse and fine middlings, both consisting of fragments of endosperm and germ with adhering branny particles. The semolina and the middlings are then treated in "purifiers," where by means of sieves and currents of air the branny and cellulose particles are largely removed, and either kept as offal or still further treated. The purified semolina and middlings are next passed through a series of reduction rollers, usually six to ten pairs, which are smooth, and run at a less differential speed than the break rollers. Between each pair of rollers the flour is sifted out, and the residue sent on to the next pair. What comes out of the last pair of all is practically free from flour.

The highest grade flour ("whites" or "patents") comes from the first few reduction rollers (top of the mill) and is derived almost entirely from the parenchymatous cells of the berry, while that from the remaining reduction rollers (bottom of the mill) and the break flour from the break rollers is classed as low grade ("household"). Ordinarily in roller-milling 70–73% of the cleaned wheat is obtained as flour, and the miller aims at getting as much of his flour from the reduction rollers, and as little from the break rollers, as possible. Usually half the flour obtained is white and half household. If all the flour from a mill is mixed together it is known as a "straight run" flour. When the whole of products of milling are included in the flour, the mixture is known as whole-meal.

The germ or embryo, in addition to its richness in phosphorus compounds, contains much anti-neuritic vitamine, without which a diet consisting mainly of white bread may cause serious risk to health. In stone-milling much of the germ passes away in the offal, while in roller-milling it is entirely removed from the flour. Millers object to mixing the germ with the flour, as they say that rancidity is developed as a result of oxidation of the oily constituents of the germ, and, furthermore, that the baking qualities of such flour are impaired. The germ may be heated to prevent the development of rancidity, and some flours are sold containing as much as 25% of germ treated in this way.

"Standard Flour" is flour containing 80% of the grain. It includes practically the whole of the parenchymatous cells, the germ, and the finer branny particles. It has also been described as consisting of "80% of the grain with all the germ and semolina." It may be prepared either by stone or roller mills.

The average percentage composition of the various flours is—

	Patent flour.	Whole meal.	Standard flour.
Water	10·55	8·61	14·43
Protein	11·08	12·65	11·8
Fat	1·15	2·44	1·62
Carbohydrate	78·85	74·58	72·2
Ash	0·37	1·72	0·68
P_2O_5	0·15	0·71	0·35

Whole meal is slightly richer in protein than white flour, but the difference is not great. It may actually be found that white flour made from one variety of wheat contains more protein than whole-meal from another. Wheats vary considerably in composition. Further, whole-meal is not so readily digested by many people, so that any increase in the amount of protein ingested is more than counterbalanced by what is lost in the fæces. Whole-meal is of benefit at times to individuals suffering from constipation, and it is said, although without much foundation, to be less provocative of dental caries. In cases where the diet consists mainly of bread, especially among the poorer classes, it is certainly advisable to use whole-meal, on account of its anti-neuritic vitamine content.

A "strong" flour is one that produces a large, well-risen loaf. This property is due to the presence of gluten, and can apparently be modified by the action of certain salts and acids. The ash of strong wheats, for example, is said to be richer in phosphates than that of weaker grades. Attempts have been made to increase the strength and water-absorbing capacity of weaker flours by the addition of certain substances known as "improvers," with a view to getting a greater number of loaves from a given quantity of flour and to stimulating the activity of yeast in bread-making. "Improvers" are usually phosphates in one form or another (acid potassium phosphate, acid magnesium phosphate, acid calcium phosphate); such phosphates have at times been found to contain arsenic in appreciable quantities, and their manufacture should be carefully controlled.

The public demand for white flour has resulted in the bleaching of flour. Flour has naturally a faint yellow tinge. Bleaching is usually performed by nitrogen peroxide produced chemically or electrically. Air charged with the gas is brought into contact with the flour in a special agitator. A certain amount of the

nitrogen peroxide is retained in the flour, and Hamill suggested that more than 1 part of nitrite per million indicated artificial bleaching. The natural colouring matter of flour (carrotene) tends to be discharged during the natural ageing of flour, and nitrite is present to some extent in unbleached flour. Monier Williams pointed out that, if the Griess-Ilosvay test is used, unbleached flour should not show more than 1·5–2·0 parts of nitrite per million. Bleaching increases the solubility of the proteins and carbohydrates of the flour, indicating definite change in the chemical composition as a result of the process. In addition, nitrites have an inhibitory effect on digestive processes and enzymes. Overbleaching must be considered as potentially harmful to health (L.G.B. Food Reports, No. 12, 1911, and No. 19, 1912).

Bread.—The properties of dough are due to the gluten it contains. This gluten, when treated with CO_2, expands and forms the minute cavities to which the porosity of bread is due.

The CO_2 is produced either by the action of yeast, which ferments a small portion of the starch, forming alcohol and CO_2, or by baking-powder, which gives off CO_2 when moistened, or by using water charged with CO_2 in the process of dough-making (aerated bread).

The average composition of bread may be taken as—

Water, 40%; starch, 50%; proteins, 8%; fat, 0·5%; salts, 1·5%.

The crust usually contains about 16% moisture and the crumb from 40–45%.

A sack of flour contains 280 lbs., and about ninety four-pound loaves can usually be made from it. The temperature reached during baking rarely exceeds 100° C. in the centre of a four-pound loaf. Adulteration is rare. Boiled potatoes in small amount may be added. Alum used to be a common adulterant. It checks fermentation and produces a white loaf. It is present naturally in small amount—about two grains per pound.

Baking-powders (L.G.B. Food Report, No. 13, 1911) usually contain an acid salt and bicarbonate of soda with a starch diluent. In the presence of moisture CO_2 is evolved. The acid salt is either a tartaric acid one or acid calcium phosphate. Self-raising flour is simply flour to which a measured amount of baking-powder has been added. Acid calcium phosphate may contain large quantities of calcium sulphate as an impurity—10% should be regarded as the allowable limit. "The addition of appreciable quantities of needless mineral matter, which contributes nothing to the value of the baking-powder, is to be deprecated." Furthermore, arsenic has been detected in acid calcium phosphate and tartaric acid preparations in amounts exceeding the limit of $\frac{1}{100}$ of a grain per pound, as laid down by the Commission.

Such impurity is due to the manufacture of sulphuric acid from pyrites.

Custard powders consist, as a rule, of maize starch and some colouring and flavouring matters. They are in no way a substitute for eggs.

OTHER VEGETABLE FOODS

Barley contains rather more proteins than wheat-flour, oatmeal more protein and fat; rye-flour is very similar to ordinary flour; maize or Indian corn has from 5–8% of fat.

Rice is composed mainly of carbohydrate with a small amount of protein. Modern methods of milling remove all the outer husk and leave nothing but the original endosperm. The rice grains are frequently polished by talc (consisting mainly of silica and magnesia) or other similar substance. They may also be treated with certain blue pigments to increase whiteness, and with vegetable oils to increase translucency. It has been proved conclusively that beri-beri in natives is usually due to the consumption of this polished rice, which has lost all the portions of the grain containing anti-beri-beri vitamine.

Beans, peas, lentils are of considerable nutritive value on account of the large amount of nitrogenous matter they contain. The protein exists mainly as legumin and is not so digestible as meat protein. They are also deficient in fat as compared with meat. Lathyrism is a condition of gastro-intestinal disturbance, with even paraplegic and other nervous symptoms, said to be due to the consumption of Lathyrus sativus, one of the vetches. The value of germinating pulses in beri-beri has already been noted.

Potatoes consist mainly of water and starch. Cases of poisoning from the consumption of sprouting potatoes have been attributed to solanin, but, as is mentioned elsewhere, the condition was probably of bacterial origin. Arrowroot is a prepared starch from the roots of the marantaceæ. It is obtained chiefly from the West Indies and South Africa. Many starches are sold as arrowroot which are derived from plants other than the marantaceæ, and the genuine article is liable to adulteration with cheaper starches. Tapioca is got from the cassava plant, and sago from palm-pith; both consist almost entirely of starch and water.

PARASITES IN CEREALS

Animal.—The weevil or calandra granaria and the ear cockle or vibrio tritici are both found in wheat. Acarus farinæ is found in flour.

Vegetable.—Claviceps purpurea is found principally in rye, the mycelial growth being known as ergot; "smut" or uredo segetum affects chiefly rye, barley and oats; "bunt" or uredo fœtida and "rust" or puccinia graminis attack wheat. The ordinary moulds

—aspergillus, mucor and penicillium—may be observed in grain generally, if damp and unhealthy.

BEVERAGES

Alcoholic.—Ethyl alcohol is obtained from the fermentation of glucose, $C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$. It has a specific gravity of 0·793, boils at 173° F., and freezes at −203° F. "Proof spirit" is a mixture (57% by volume) of alcohol and water, and the strength of distilled spirits is usually expressed in this country in terms of proof spirit. A spirit is under or over proof according to whether it contains less or more alcohol than does this standard.

Brandy should be made solely from fermented grape juice. Its colour is due to storage in casks and the addition of caramelised grape sugar. Alcohol in pre-war days used to amount to about 50% by weight. The aroma of brandy is due to various higher ethers, etc., and their presence serves to differentiate the real article from grain spirit, which is frequently used as a substitute. Whisky is made mostly from barley, both malted and raw. The colour is due to storage in sherry casks. Distillation may be done by either patent-still or pot-still processes. Fusel oil or amylic alcohol is liable to be present in considerable quantity in new whisky. The alcohol percentage used to be slightly higher than that of brandy. Rum is distilled from the fermented juice of the sugar-cane. Gin is made from grain and flavoured with juniper berries, etc. Both contain much the same amount of alcohol as whisky. By the Sale of Food and Drugs (Amendment) Act, 1879, whisky, brandy and rum must not be more than 25° under proof and gin 35°. These standards were considerably lowered during the War. By a Defence of the Realm order, whisky, brandy, rum, and gin must be reduced to 25° under proof. Adulteration is not recognised till the spirit is diluted to more than 50° under proof.

Beer used to be made from malt or germinating barley with the addition of hops, but nowadays beers are made from any fermented saccharine infusion, and any wholesome bitter may be added. The wort is the unfermented saccharine infusion containing the hop bitters, and it is on the strength of this wort that Excise Duty is levied. The specific gravity of the wort is known as the "original gravity." Beer manufactured from glucose has been known to cause outbreaks of arsenical poisoning, the source of the poison being the sulphuric acid used for the inversion of starch to glucose. Stout owes its dark colour to roasted malt.

Wine is the fermented juice of the grape. Fermentation proceeds naturally without the addition of yeast. White wine is usually more acid than red. Brandy is often added to sweet wines to prevent further fermentation of the sugar. "Plastering" of wine means the addition of calcium sulphate. It aids

keeping by removal of acidity and assists clarification. As a result of this process potassium sulphate tends to be formed and, as an excess of this might be somewhat harmful, not more than 2 grams of this salt per litre are allowed in France. Pasteurisation is frequently practised in France. It prolongs the life of a wine and is said to give an artificial flavour of age. Wine that develops "ropiness" may be renovated by this treatment. Acetous fermentation is apt to be set up in wine stored in casks, etc., that are not airtight. This results in the formation of acetic acid from some of the alcohol. Much artificial wine is made from dried raisins. Artificial colouring matter, especially log-wood, may be added to wines, and salicylic acid has been used as a preservative.

The Action of Alcohol on the Body. (*Alcohol—its Action on the Human Organism*, H.M. Stationery Office, 1918.)

Alcohol acts mainly on the nervous system. It is really a sedative, and, with the possible exception of its action on the respiratory centre, it never stimulates. The control exercised normally by the higher centres is removed, and the result is "decrease of critical self-consciousness." A dose which produces no change in the performance of a simple act will definitely impair the precision of an act demanding greater delicacy and co-ordination. The stimulant action popularly attributed to alcohol is really due to a relaxation of tension. In this way, if worry is likely to interfere with digestion, a little dilute alcohol may aid assimilation of food. Similarly the narcotic action is useful in sleeplessness. In cases of fainting from pain or fright it is of use in weakening "the excessive check on the heart's action exercised by the nervous centres, and, on account of its sedative influence on the higher levels of the brain, in relieving pain and anxiety."

As a food it is absorbed very rapidly, and requires no digestion before entering the blood. It is therefore useful in acute diseases. It is, however, out of place as an ordinary source of energy on account of its harmful action on the higher centres. Furthermore, it cannot be stored in the body to be drawn upon as required. It remains as alcohol in the blood till destroyed by combustion. Thus, if it is taken frequently, the tissues are never free from it, and the changes found in chronic alcoholism are produced. Beer has a definite nutritive value due to dextrin and other carbohydrate bodies it contains. More than half the food value, however, of ordinary beer is derived from its alcohol content.

In 1901 there were consumed per head of the population in the United Kingdom, 31·24 gallons of beer, 1·09 gallons of proof spirit, and 0·36 gallon of wine, as compared with 21·49, 0·52, and 0·20 respectively in 1917.

Insurance companies have found that the expectation of life is some three and a half years less in the case of non-abstainers than for total abstainers.

COMPARATIVE MORTALITY TABLES OF MALES AGED TWENTY-FIVE TO SIXTY-FIVE YEARS, 1910–1912.

Group.	Alcoholism.	Alcoholism and liver diseases.	All causes.
All males	7	23	790
Commercial travellers	9	32	724
Coachmen, busmen	12	29	921
Messengers, porters	13	33	1137
Seamen	18	34	1485
General labourers	20	50	2301
Dock labourers	26	43	1127
Hawkers	30	52	1507
Publicans, innkeepers	50	152	1265

PERCENTAGE OF PROOF SPIRIT AND ABSOLUTE ALCOHOL IN VARIOUS BEVERAGES[1]

	Original gravity.	Percentage of proof spirit.	Percentage of absolute alcohol (by weight).	Percentage of absolute alcohol (by volume).
Spirits—				
at 25° u.p.	—	75·0	35·9	42·8
at 30° u.p.	—	70·0	33·3	40·0
at 35° u.p.	—	65·0	30·8	37·1
at 40° u.p.	—	60·0	28·3	34·3
at 50° u.p.	—	50·0	23·4	28·6
Wines—				
Port	—	35·3	16·4	20·2
Sherry	—	29·5	13·7	16·9
Madeira	—	28·9	13·4	16·5
Tarragona	—	27·2	12·6	15·5
Australian Burgundy	—	24·8	11·5	14·2
Italian Red Wine	—	23·9	11·1	13·7
Champagne	—	23·6	10·9	13·5
French Burgundy (Red)	—	22·1	10·2	12·6
Californian Burgundy	—	20·8	9·6	11·9
Italian White Wine	—	20·6	9·5	11·8
French Burgundy (White)	—	20·2	9·3	11·6
Bordeaux (White)	—	19·9	9·1	11·4
„ (Red)	—	17·0	7·8	9·7
Cider (bottled)	—	7·4	3·4	4·2
Beers (English)—				
Pale or Bitter Ale	1060·2	11·1	5·1	6·4
London Stout	1064·6	9·7	4·4	5·5
Burton Ale	1053·2	9·4	4·3	5·4
Light Pale Ale	1042·6	7·9	3·6	4·5
Mild Ale (No. 1)	1037·8	5·8	2·6	3·3
Porter	1041·5	4·3	1·9	2·4
Mild Ale (No. 2)	1016·5	2·8	1·3	1·6
Beers (Import)—				
Dutch (1916)	1053·5	9·8	4·5	5·6
Danish (1916)	1057·6	8·8	4·0	5·0
Norwegian (1916)	1042·4	6·8	3·1	3·9
Pilsener Lager (Pre-War)	1054·0	9·4	4·3	5·4
Munich Lager (Pre-War)	1057·0	8·8	4·0	5·0

[1] Appendix IV. *Alcohol—its Action on the Human System.*

Cider and perry, on account of their acidity, may have a solvent action on lead, and have been known to cause symptoms of lead poisoning.

Non-Alcoholic Beverages.—Temperance wines are liable to contain considerable quantities of preservatives, notably salicylic acid.

Natural mineral waters, as a rule, are remarkably free from bacteria of any sort, but faulty methods of bottling may render them very impure. It is a wise precaution in cases of doubt to store the bottles for a fortnight before use, as pathogenic organisms are unlikely to survive for longer. The ordinary aerated-water siphon frequently shows gross bacterial contamination, and traces of such metals as copper or lead are occasionally found in the contents.

Tea.—Black tea-leaves have undergone some slight fermentation before being baked, green tea is baked immediately after being picked.

Characteristics of the tea-leaf—notched apex, serrated margin, serrations tipped with spines, looped venation of primary veins. Under the microscope the under surface of the leaf shows well-marked stomata and unicellular hairs.

Theine (or caffein), 1·5–5%, is constantly present. These needle-shaped crystals are not found in exhausted tea—*i. e.* tea-leaves that have been previously used. As tea is examined carefully by the Customs officers, the old practices of adulteration with foreign leaves, facing of green tea with indigo or Prussian blue, etc., have practically disappeared.

Coffee—the seeds of the Coffea Arabica. In the natural state two seeds are contained inside the fruit. These seeds are roasted before use in order to develop aroma, flavour and colour. A volatile oil, known as caffeol, is produced in the process, and to it most of the aroma and taste are due. Coffee contains just over 1% of caffeine (theine) and about 13% of oily matter. Chicory (prepared from the root of the wild endive) is a common adulterant. The main points of difference are—

(*a*) Coffee floats on water and stains it but very little, whereas chicory sinks at once and colours the water brown.

(*b*) Coffee contains crystals of caffeine, chicory does not.

(*c*) Microscopically coffee shows spindle-shaped cells with a dotted appearance, chicory shows spiral ducts with square-cut ends.

Cocoa is made by roasting and grinding the seeds (called cocoa beans) of Theobroma cacao. The seeds contain about 50% of fat and 1·3% of theobromine (similar to caffeine). The large amount of fat or "cocoa-butter" makes the natural product somewhat indigestible, so it is frequently mixed with starch and sugar. This is not a legal offence if the mixture is declared

on the label. "Soluble Cocoa" has an alkali added to it, which emulsifies the fat and produces a more homogeneous mixture with water. Chocolate is a preparation of cocoa, sugar, starch and added cocoa fat, flavoured with vanillin and pressed into a cake.

Lime Juice and **Lemon Juice** are expressed from the ripe fruits. They contain about 30 grains of citric acid per ounce. Brandy is frequently added as a preservative, or the juice may be pasteurised or boiled to aid keeping. In other cases salicylic acid is used. Under the Merchant Shipping Act, a daily ration of 1 oz. of such juice, in the absence of fresh vegetables, must be served out on ships ten days after leaving harbour. Lemon juice was a valuable antiscorbutic when first used as such many years ago, but of recent years it has been largely replaced by lime juice, which contains less antiscorbutic vitamine and loses a portion of what it naturally possesses on account of modern methods of preparation. Much fictitious juice is made from citric or tartaric acid with the appropriate flavourings. Lime juice cordial is simply lime juice sweetened with sugar. It usually contains a preservative such as salicylic acid.

Vinegar.—Malt vinegar may be made either from malted barley or other cereals. The malt is mashed and soaked in successive quantities of hot water till all soluble material is extracted. To this extract yeast is added and fermentation is allowed to proceed for three to four days. The fermented liquor is next pumped through an acetifier, where it is sprayed over birch twigs, etc., on which the mycoderma aceti grows. In the presence of a sufficient supply of oxygen and a suitable temperature most of the alcohol is converted into acetic acid. Small amounts of other bodies, *e. g.* acetic ether and aldehydes, are formed which give malt vinegar its characteristic flavour. A little alcohol should be left, as it improves the flavour and acts as a preservative. The vinegar is subsequently clarified either by filtration or precipitation. Potassium ferrocyanide has been used for this purpose, but is not free from objection. Distilled vinegar is made by distilling malt vinegar. Wine vinegar is best made from white wine. Spirit vinegar is prepared by the acetous fermentation of dilute distilled alcohol, chiefly potato spirit. Vinegar should contain not less than 4% acetic acid, and no other acid, no lead or copper, and no colouring matter other than caramel should be present. There are, however, no legal standards. Artificial vinegar is made usually by diluting acetic acid (pyroligneous or wood acid). It may be coloured with caramel. Sulphuric acid is at times used as an adulterant; action in such cases may be taken under the Sale of Food and Drugs Act. Salicylic acid and calcium bisulphite have been detected as preservatives. Occasionally pasteurisation is practised as a means of preserving. Metals such as lead, copper, and arsenic may enter the vinegar

during the process of manufacture. Added to tinned foods, vinegar tends to exercise a solvent action on metals.

PRESERVATION OF FOODSTUFFS

Decomposition of food is due to the multiplication of bacteria. These will grow, as a rule, only between certain temperatures (10°–40° C.), and in the presence of moisture and air. The addition of chemical substances may retard their growth.

1. **Heat Sterilisation.**—This is practised in canning processes. Air is excluded from the tins and putrefaction of the contents prevented. It must be remembered, however, that experiment has proved that real sterilisation is frequently not achieved, organisms and their spores remaining alive at the end of the process.

The method of canning meat is as follows: The meat is frequently pickled in the first instance (*e. g.* tongues). It is then partially cooked, cut up into proper portions and packed in the tins. The lid is soldered on and a vent hole is left to allow escape of steam during subsequent heating. In the open vat process the filled cans are immersed for about three-quarters of their height in a vat of boiling calcium chloride solution. After remaining there some time they are removed and the vent holes are soldered over. The next step is to immerse the tins completely in a similar vat for a still longer period. Occasionally the original vent hole is reopened to allow any steam or gas to escape, and even a second vent hole may be made, and the tin, after resoldering, subjected to a third heating. Two solder marks are, however, apt to be looked on with suspicion, as the second may have been made to allow of escape of gas from a "blown tin." In the "retort process" an autoclave heated by steam under pressure is substituted for the open vat.

The best type of can is moulded out of a single piece of tinplate, so that the only soldered joint necessary is that holding the lid in position. Lids may even be clamped on by a special machine and soldered unions done away with altogether. A small cup of tin is frequently attached to the under surface of the lid just below the site of the vent hole, in order to prevent any solder dropping into the contents of the tin. These precautions are necessary, as lead poisoning might result from consumption of food containing solder. (Solder should not contain more than 10% of lead.)

Tin is frequently found in the contents, especially in canned food that has been kept for long periods, and poisonous symptoms have been produced by food containing 15–20 grains of tin per pound. Two grains of tin per pound may be considered as an amount causing risk to health (L.G.B. Report on the Presence of Tin in Certain Canned Foods, 1908). It is the more acid substances

that tend to dissolve metals, *e. g.* vinegar, plums, asparagus, cherries, pears, apricots. Lacquered tins may be employed as containers for such foods.

In inspecting a consignment of tinned food, about 5% should be examined. A good tin shows concave ends on account of a partial vacuum produced inside on cooling. A "blown tin" is one with convex ends, which gives a resonant note when tapped. "Blowing" is due to the development of gases of putrefaction, the result frequently of the growth of spores of B. cadaveris which are not killed at the temperature usually reached in the inside of large tins. Beveridge found that, in a calcium chloride bath with a temperature of 107° C., the centre of a 2 lb. tin reached 105° C. only after 123 minutes. Freezing of the contents of tins in cold storage may cause bulging, as may also electrolytic action set up between the acids inside and the metals of the tin. Local bulging may be due to rough handling. In cases of doubt the tin should be punctured under water, when the contained gases will bubble out. Tins should be discarded if they are "blown," if there is any perforation or marked indentation, if they are very rusty, or if the contents are unduly movable when the tin is shaken. When the tin is opened putrefaction is indicated by unpleasant smell, discoloration of contents and an undue softness of such substances as gelatine.

Glass dishes have replaced tins to a certain extent of recent years, and instances have been known where food shipped to this country in tins has been repacked in glass vessels prior to sale. Such containers are good in that the purchaser can see to some extent what he is buying, but it must be remembered that glass withstands heat less well than tins, and the "sterilising" temperature reached is likely to be lower on that account. Food packed in glass vessels frequently contains preservatives. Such containers are usually closed by a metal lid with a rubber washer, the whole being kept in position by a partial vacuum inside.

2. **Cold.**—A low temperature merely inhibits bacterial growth. Meat is imported in huge quantities to this country either frozen or chilled. In the former case a temperature of 10° F. is employed, and in the latter from 30°–35° F. Such meat must be kept in cold storage in this country prior to sale. The common method of producing low temperatures for cold storage is by compression and then sudden expansion of a gas such as ammonia. The resultant cold is communicated either to pipes of brine which circulate through the various store-rooms, or to air which is blown into the chambers by means of a fan. Frequently an ice factory and cold storage are combined.

Butter, fruit, etc., may also be preserved in this way, and it has already been shown that milk will keep sweet for a considerable time if cooled immediately after milking.

Frozen meat is pink in colour, due to diffusion of hæmoglobin,

and the fat is very white. It is generally moist, and the surface has a dirty appearance. Decomposition may be detected by cutting into the region of the hip-joint. Chilled beef has a deeper red colour, and the fat is usually slightly pink. Occasionally the legs show bruising, due to American methods of slaughter.

3. **Drying** preserves by excluding the moisture that is necessary for bacterial growth. Vegetables, fruit, eggs, milk, and various meat preparations may be so treated.

4. **Exclusion of air** is adopted in the preservation of eggs by coating with sodium silicate.

5. **Smoking** is a common method of treating fish and meat. Smoke from beechwood chips is frequently employed. It is thought that the creosote in the smoke is possibly antiseptic. Bacteria and even spores can be killed by direct exposure to smoke, but as an albuminous layer tends to form on the surface of food under similar conditions the penetrating power of the smoke is not great.

6. **Chemical Preservatives.**—Salt is the commonest of all, and is at times combined with saltpetre. Rarely more than 2% is now added. It has only an inhibitory effect on organisms, and in large amount may prove harmful to persons suffering from gout, renal disease, etc.

Boron compounds (usually a mixture of boric acid and borax) are largely used for preserving meats (such as hams, sausages, potted meats, meat extracts, etc.), beverages, butter, cream, etc. They are only feebly germicidal—a 4% solution will not kill anthrax spores. They are inhibitory in action, and as small an amount as 0·05% will delay souring of milk for a considerable time without having any detrimental effect on any pathogenic organisms that may be present. Hams only partially cured can be imported into this country packed in borax—the muscle substance appears to be penetrated by borax very much more than the fat. Boron compounds are recognised pharmacopœial drugs and have a slight cumulative action. They are eliminated by the kidneys.

Formaldehyde is used to disinfect the cold chambers of vessels carrying meat, and may be applied to the surface of carcases. Appreciable amounts have been detected in the meat so treated (L.G.B. Report, New Series, No. 12, 1909). Skin rashes have been attributed to its use as a preservative in milk, in the days when such a practice was not illegal.

Sulphurous acid has been used in beer, etc. Salicylic acid is a common preservative for non-alcoholic wines and cordials, etc., and is found also in jams. Benzoic acid and fluorine compounds have also been found in foods. Hydrogen peroxide is used largely for preserving cream (see Budde Process, p. 95).

Arguments against the use of chemical preservatives—

1. **Such substances are all drugs whose potency is recognised**

by the Pharmacopœia, and experiments on animals and human beings tend to show that their continued use is not without harm. They also delay artificial digestion.

2. So many foods are liable to contain preservatives that an individual may consume an appreciable quantity in the course of a day.

3. Preservatives are added to delay putrefaction, and they tend to cloak unclean methods of preparation and the use of stale or inferior food. They are employed really in the interests of the manufacturer, and it has been shown time and again that foodstuffs, if good in the first instance and well handled, will keep satisfactorily without their addition.

4. Finally, preservatives have been forbidden by law in certain foods, such as milk and cream (containing less than 35% by weight of fat).

Experiments regarding preservatives have been carried out on the following lines—

1. Artificial digestion experiments (salivary, peptic and pancreatic).
2. Feeding to animals.
3. Feeding experiments on healthy adults (Wiley).

ARTIFICIAL COLOURING MATTER IN FOODS

1. Injurious colouring matters are metallic salts (of lead, arsenic, copper, chromium, etc.) and aniline dyes such as rose aniline, methylene blue, gentian violet, Bismarck brown.

2. Harmless colouring matters are usually vegetable in origin (logwood, annatto, turmeric) and sometimes animal (cochineal).

Copper sulphate is used in the greening of tinned peas, and apparently the colour formed is due to a combination of the copper and a chlorophyll derivative. If too much copper is added a leguminate is formed which is said to be soluble to some extent in the gastric juice. The practice is a bad one.

Milk and butter are frequently coloured with annatto, and confectionery, wines, potted meats, sausages and many other foodstuffs are very commonly coloured artificially.

The practice is almost as objectionable as that of adding preservatives to food, but the addition is frequently so apparent that the public only have themselves to blame for the purchase of such articles.

SECTION VI

INFANTILE MORTALITY, MATERNITY AND CHILD WELFARE, SCHOOL HYGIENE

INFANTILE MORTALITY

The questions of Infantile Mortality and Birth-rate can never be dissociated. From the following table it will be observed that the birth-rate has been declining—

ENGLAND AND WALES—BIRTH-RATES AND DEATH-RATES

Year.	Birth-rate per 1000 of the population.	Death-rate per 1000 of the population.
1871–1875	35·5	20·9
1876–1880	35·3	19·8
1881–1885	33·5	18·7
1886–1890	31·4	18·5
1891–1895	30·5	18·5
1896–1900	29·3	17·6
1901–1905	28·2	16·0
1906–1910	26·3	14·4
1911–1914	24·0	13·5
1915	22·0	15·7 (civilian only)
1916	20·9	14·4 " "
1917	17·8	14·4 " "

According to the supplement of the Registrar-General's Report for the decennium 1901–1910, the births in England and Wales numbered 9,298,209. This gives a mean annual number of 929,821 as compared with 668,346 for 1917; 785,520 for 1916; 814,614 for 1915; 879,096 for 1914; and 881,890 for 1913. The birth-rate for 1917 was 17·8 per 1000 of the population.[1] This is the lowest recorded. It is below the rate for 1916 by 3·1, and for 1914 by 6. It is not the decrease alone that is alarming, but the apportionment of this decrease. The number of births is tending to decrease among the healthiest, the most successful and the best-educated sections of the population. That the birth-rate will continue to decline is inevitable, owing to the loss of so many men in the War who, in the natural course of events, would have become fathers. Other causes of the decline are: (1) a larger proportion of celibacy, (2) postponement of marriage, (3) more easily obtained divorce (usually at child-bearing ages), and (4) the deliberate avoidance of child-bearing. The last is probably the most important factor.

[1] The rate for 1918 was 17·7, and the provisional rate for 1919 is 18·5.

During the past thirty years the population of England and Wales has increased by about 25 %, and yet the excess of births over deaths has remained practically the same, that is, in the neighbourhood of 450,000. The increment would even have decreased, if the death-rate had not declined *pari passu* with the birth-rate. This parallel decline, therefore, has been the means of partially disguising the seriousness of the situation. That there must be a stop to the falling death-rate is obvious, otherwise in the course of the next two or three generations our population will be a stationary one. There are two solutions to the problem: either the birth-rate must be increased, or the infantile mortality rate must be still further reduced. Whether a reduction of the infantile mortality rate will tend towards racial fitness is, in the opinion of many, an open question. If, as they say, the deaths under one year of age are selected, and in the main those who succumb to the ravages of disease and circumstance are those who are unable to withstand the strain of the first year of infant life, then a reduced infantile mortality rate will assuredly be the means of increasing the "delicacy rate" at a subsequent age period. The survival of the unfit will result in an increased proportion of the physically inferior. Owing to the special risks to which infants are subjected, and to their physiological disabilities, the death-rate under one year of age must be higher than that for any other age, excepting, of course, that for the other extreme of life.

The Registrar-General in 1911 tabulated the infant mortality rates in classes, according to the fathers' occupations. Among doctors, clergymen, Army officers and other professional classes the rate was about 50 per 1000 births. Among general labourers, ironworkers, scavengers and hawkers the rate was over 150. It might be contended that these are not comparable, as the professional classes have more money, and therefore are able to provide more and better food, etc., and that comparisons are being drawn between two sections of a community. If whole communities are selected, rural areas have almost invariably a much lower rate than that of urban areas, more particularly if the urban areas are industrial centres. The rate for these rural areas, as a rule, falls between 50 and 60 per 1000 births. In the United Kingdom in the year 1914 there were registered 1,101,836 births, and 114,591 deaths under one year, giving an infantile mortality rate of 104. If the rate had been 50, the deaths would have numbered only 55,092, a saving of nearly 60,000 lives. Moreover, it may be added that the environmental differences between urban and rural communities appear to affect the mortality rates for the second, third, fourth and fifth years of life to an even more pronounced degree than that for the first year of life. When this is considered along with the fact that those counties which have high infantile mortality rates almost

invariably have high death-rates for the age period one to five years, it is strong presumptive evidence that the question does come within the range of preventive medicine.

The infantile mortality rates for each year from 1901 to 1917 are shown in the following table—

INFANTILE MORTALITY IN ENGLAND AND WALES, 1901–1917[1]

Year.	Deaths under 1 year per 1000 births.
1901	151
1902	133
1903	132
1904	145
1905	128
1906	132
1907	118
1908	120
1909	109
1910	105
1911	130
1912	95
1913	108
1914	105
1915	110
1916	91
1917	96

It will be seen that prior to 1907 there was no marked decline, in spite of a downward trend of the general death-rate. During recent years, however, the fall has been more marked, save in 1911, which was an exceptional year, owing to a prolonged spell of hot and dry weather. What administrative measures synchronise with this reduction is not clearly established. If these rates be compared with those of Bradford, a town which has attacked the problem with great zeal and enthusiasm, they will be found to be distinctly favourable. This would suggest either that the stringent measures which Bradford has adopted have been unavailing, or that the anticipated results have not as yet had time to appear. The infantile mortality rate is not comparable year by year unless the number of registered births remains more or less a constant. It is obvious that the births of one year will contribute towards the infantile deaths occurring in the ensuing year. If the birth-rate were suddenly to decline, then the total births in that particular year would not represent the true population which furnished the infantile deaths in the same year.

[1] The rate for 1918 was 97 per 1000 births. The provisional rate for 1919 is 89, *i. e.* 2 per 1000 below the rate for 1916. In 1916, however, the birth-rate was falling, while in 1919 it was rising.

Among the possible causes of infantile mortality (on which there is no unanimity of opinion) may be included poverty, defective sanitation, atmospheric pollution, bad housing, overcrowding, want of breast-feeding, inanition of mother and child, maternal ignorance, negligence, and outdoor occupation. The evidence, however, is exceedingly conflicting. Poverty, bad housing, defective sanitation, etc., are just as rife in rural areas as in urban communities, and yet it has been pointed out that infantile mortality in rural areas is much lower than in urban. The outdoor occupation of married women is said to exercise a harmful effect upon the children of these women. This is exemplified in the case of Lancashire. But Lancashire is not the only county with a high infantile mortality rate. The rate for Glamorganshire is equally high, and yet the percentage number of married women employed out of their homes is much lower in this county. It must be admitted that our knowledge of the factors, environmental and otherwise, which lead to disease and death is gravely incomplete. There can, however, be no doubt that an imperfect midwifery service contributes very largely to many preventable conditions such as blindness, and that bad housing, overcrowding, insanitation, infected food, and general apathy and ignorance exact a heavy toll on infant life. These same evils scar and maim many thousands who survive, and make their presence felt right through life.

If the mortality rates be calculated for each month of the first year of life, and not for the year as a whole, it will be seen that the decline has occurred mainly in the second half of the year. This would suggest that post-natal measures have proved more successful than ante-natal.

ENGLAND AND WALES—AGE DISTRIBUTION OF INFANT MORTALITY, 1905–1917

(*Deaths per thousand births registered.*)

Year.	Under 4 weeks.	4 weeks to 3 months.	Total under 3 months.	3–6 months.	6–12 months.
1905	41	25	66	25	37
1906	42	26	68	27	38
1907	42	23	65	21	32
1908	40	24	64	24	32
1909	41	20	61	19	29
1910	38	20	58	19	28
1911	40	25	65	26	39
1912	38	18	56	15	24
1913	39	20	59	20	29
1914	39	19	58	19	28
1915	38	19	57	19	34
1916	37	17	54	15	22
1917	37	17	54	16	26

As to the pathological causes, it will be seen from the annexed table that, if the quinquennium 1906–1910 be under review, no less than 36% of the total deaths were due to developmental and wasting diseases, and 15·1% to diarrhœal diseases. Of the common infectious diseases, whooping-cough alone formed 62%. The chief causes, then, are diarrhœa, premature birth, atrophy, debility and marasmus, convulsions, bronchitis, and pneumonia.

The infantile mortality rate for 1917 is much lower, due mainly to a reduced mortality from diarrhœal and developmental diseases. On the other hand, the rates for measles, syphilis, injury at birth, and pneumonia have slightly increased.

ENGLAND AND WALES—MORTALITY RATES PER THOUSAND FOR INFANTS UNDER ONE YEAR AND UNDER FIVE YEARS FOR 1906–1910, AND FOR INFANTS UNDER ONE YEAR FOR 1917

Cause of death.	1906–1910 Under 1 year.	1906–1910 Under 5 years.	1917. Under 1 year.
1. Common infectious diseases	7·46	6·09	5·74
2. Diarrhœal diseases	17·78	5·38	10·3
3. Developmental and wasting diseases	42·16	10·44	36·55
4. Tuberculous diseases	4·41	2·61	2·75
5. Other diseases	45·27	17·23	41·14
All causes	117·08	41·75	96·48
1. Chicken Pox	0·06	0·03	0·06
Measles	2·43	2·48	2·73
Scarlet Fever	0·12	0·46	0·05
Diphtheria and Croup	0·3	0·87	0·23
Whooping Cough	4·85	2·25	2·67
2. Enteritis	2·82	0·85	
Gastro-enteritis	2·36	0·71	
Gastro-Intestinal Catarrh	0·61	0·17	
Diarrhœa (other forms)	11·99	3·65	
3. Premature birth	19·92	4·81	19·07
Congenital defects	6·63	1·67	4·3
Want of breast milk, starvation	0·77	0·19	
Atrophy, Debility, Marasmus	14·84	3·77	11·57
4. Tuberculous Meningitis	1·41	1·01	1·07
Tuber. Peritonitis. Tabes. Mesen.	1·75	0·79	0·95
Other T.B. diseases, including Phthisis	1·25	0·81	0·73
5. Syphilis	1·23	0·32	2·03
Erysipelas	0·23	0·06	0·13
Rickets	0·49	0·31	0·41
Injury at birth	0·96	0·23	1·15
Meningitis (not T.B.)	1·8	0·91	1·3
Convulsions	10·55	2·88	7·89
Laryngitis	0·16	0·18	0·16
Bronchitis	8·97	3·0	8·43
Pneumonia	10·84	5·22	11·44
Gastritis. Gastric Catarrh	1·63	0·48	1·62
Suffocation	1·69	0·42	1·05
Other causes	6·72	3·22	

If, however, the diseases grouped as developmental and wasting diseases be considered separately, premature birth and congenital defects have slightly increased. The reduction is due to the decline of atrophy, debility and marasmus. These facts will be made evident if the following table is considered—

ENGLAND AND WALES—DEATHS UNDER ONE YEAR OF AGE FROM DEVELOPMENTAL AND WASTING DISEASES PER 1000 BIRTHS 1886–1917

(Proportion of deaths per thousand births)

	1886–1890.	1891–1895.	1896–1900.	1901–1905.	1906–1910.	1911–1915.	1916.	1917.
Premature birth .	16·1	18·4	19·6	20·2	19·9	19·7	18·6	19·1
Congenital defects .	3·2	3·6	3·9	5·7	6·6	5·6	5·8	5·9
Atrophy, Debility and Marasmus	22·8	22·7	21·7	18·7	15·6	13·5	11·2	11·6

If a detailed and more minute statistical statement is required, the reader is referred to the next table, where the fluctuations of the more important diseases are given—

ENGLAND AND WALES, 1917. PERCENTAGE INCREASE OR DECREASE OF INFANT MORTALITY AS COMPARED WITH 1911–14 AND WITH 1916

Disease.	Under 4 weeks.		4 weeks to 3 months.		3–6 months.		6–9 months.		9–12 months.		Under 1 year.	
	1911–14	1916	1911–14	1916	1911–14	1916	1911–14	1916	1911–14	1916	1911–14	1916
Whooping-cough .	−36	−30	−34	−19	−37	−22	−34	−19	−27	−27	−33	−23
Other common infectious diseases		+33	−25	−14		+22	−9	+65	+7	+97	+1	+74
Diarrhœa and Enteritis . .	−34	−8	−43	−1	−48	−1	−57	−8	−54	+2	−49	−3
Premature birth .	−4	+2	−3	+6		+5			+100	+100	−4	+2
Congenital defects	+6	+1	+13	+7	+11	+2	+29	+22		−8	+8	+3
Atrophy, Debility and Marasmus .	−11		−18	+3	−18	+15	−33	+10	−28	+11	−15	+3
Developmental and Wasting diseases	−4	+1	−10	+4	−13	+12	−22	+13	−20	+7	−6	+3
Tuberculous diseases . .		+33	−16	+23	−14	+7	−14	+19	−7	+16	−12	+15
Convulsions . .	−11	+1	−8	+5	−13	+10	−14	+4	−5	+1	−11	+4
Bronchitis and Pneumonia .	+3	+15		+5	+10	+13	+12	+19	+13	+22	+8	+15
Suffocation overlying . .	−19	+3	−35	+23	−33		+17	+75			−27	+12
Other causes .	+10	+2	+8	+5	+4	+5	+9	+18	+1	+11	+7	+7
All causes . .	−5	+2	−15	+4	−19	+6	−18	+12	−11	+17	−12	+6

Among the measures for combating infantile mortality the following may be included—

1. The adoption of women Health Visitors.
2. Improved legislation.
3. Consultation Centres and Clinics.
4. Milk depots.
5. Crèches.
6. Education of the mother and expectant mother.

In conclusion, it must be stated that all the rates referred to were calculated on the total births, legitimate and illegitimate. If the two are separated, and rates made for each, then the illegitimate births without exception furnish the higher rates.

MATERNITY AND CHILD WELFARE

The Notification of Births (Extension) Act, 1915, gave Local Authorities power to make provision for the care of expectant mothers, nursing mothers, and young children, and authorised the appointment of special committees for this purpose, such committees to include women and, if thought fit, persons not members of the Authority.

The Maternity and Child Welfare Act, 1918, repeats the provisions of the previous Act regarding Welfare schemes, and includes children up to five years of age, who are not being educated in schools recognised by the Board of Education. Every Council establishing such a Centre must appoint a special committee, which may include specially qualified persons who are not members of the Council, and must include two women, but not less than two-thirds of the committee must consist of members of the Council.

Inasmuch as the Councils of Counties and County Boroughs are the local supervising authorities under the Midwives Act, 1902, and are responsible for tuberculosis schemes, it secures unification of home-visiting, etc., if Maternity and Child Welfare organisation is undertaken by them. If a general scheme is drawn up for a county, the work should be carried on in close co-operation with the various Sanitary Authorities.

A complete scheme includes the following—

1. Arrangements for the local supervision of midwives.
2. Arrangements for—
   (*a*) An Ante-natal Clinic for expectant mothers.
   (*b*) The home visiting of expectant mothers.
   (*c*) A Maternity Hospital, or beds at a hospital, in which complicated cases of pregnancy can receive treatment.
3. Arrangements for—
   (*a*) Such assistance as may be needed to ensure the mother having skilled and prompt attendance during confinement at home.

(b) The confinement of sick women, including women having contracted pelves or suffering from any other condition involving danger to the mother or infant, at a hospital.

4. Arrangements for—

(a) The treatment in a hospital of complications arising after parturition, whether in the mother or in the infant.

(b) The provision of systematic advice and treatment for infants at a Baby Clinic or Infant Dispensary.

(c) The continuance of these Clinics and Dispensaries, so as to be available for children up to the age when they are entered on a school register.

(d) The systematic home visitation of infants and children not on a school register.

The Notification of Births (Extension) Act, 1915, has made compulsory notification of all births to the M.O.H., with the result that Health Visitors may be very usefully employed in visiting women after child-birth.

The L.G.B. have issued various circulars and memoranda. The two most useful are the Circular (M. and C. W. 4) of August 1918 and the Memorandum of 1916. The following suggestions have been extracted mainly from these sources—

1. **Inspection of Midwives** at least once a quarter by competent inspectors, preferably medical women.

2. **Provision of Midwifery.**—Local Authorities should see that a sufficient number of trained women are available, their status raised, and their remuneration adequate. A trained midwife should be able to secure from £120–£150 a year. Local Authorities may pay or guarantee their salaries. The ordinary fee of the district should be charged for a confinement unless the patient is obviously unable to pay.

3. **Doctor's Fees.**—When the doctor is called in by a midwife his fee should be guaranteed by Local Authorities in the case of necessitous persons. It should be arranged that a doctor should always be available in cases of urgency.

4. **Health Visitors.**—Their duties consist in visiting and supervising all children under school age needing their attention; visiting of expectant mothers when necessary; inquiring into still-births and deaths of young children; and attendance at the Centre. One Health Visitor should be appointed for every 400 births.

As prescribed by the Health Visitors Order, 1909, their qualifications should be—

(a) Medical Degree, or

(b) The full training of a nurse, or

(c) C.M.B. certificate, or

(d) Some nursing training and the Health Visitor's certificate of a society approved by the L.G.B., or

(e) The previous discharge of duties of a similar character in the service of a Local Authority.

The certificate of a Sanitary Inspector is also valuable. The L.G.B. are not prepared to pay a grant in respect of a Health Visitor's salary unless they have distinct evidence, as above, that she is qualified for the work. In certain cases, the Health Visitor may hold other offices, such as Tuberculosis Nurse, School Nurse, and Mental Deficiency Visitor. When practicable, it is desirable that the Health Visitor and the Infant Protection Visitor (under the Children Act, 1908) should be the same person. In any case the salary should not be less than £120 a year.

Under the Board of Education (Health Visitors' Training) Regulations, 1919, future Health Visitors will be required to complete a two-years course at a recognised school attached to a University. Fully trained nurses and whole-time Health Visitors of not less than three years standing need only attend the special course for one year.

Voluntary workers may usefully assist at the Centres, and in the supervision of older children.

5. **Nursing.**—Nurses may be provided for the home-nursing of cases of puerperal fever, measles, whooping-cough, epidemic diarrhœa, and ophthalmia neonatorum. Special nurses may be appointed, and these in their spare time should act as Health Visitors. It is often convenient to make arrangements with a District Nursing Association for the services of nurses during prevalence of infectious disease.

6. **Centres.**—When practicable there should be a Centre in each Health Visitor's district. Their chief value is to provide medical and especially hygienic advice. Mothers should be urged to bring their children, whether ailing or not. If possible the same doctor should attend at stated intervals. Cases requiring treatment should be referred either to their own medical attendant or else to a hospital. Ophthalmic and dental cases may be treated at the school Clinic.

Cots may be provided at Centres for the in-patient treatment of infants other than those suffering from acute illness or infectious disease. A maximum of two wards, with four cots in each, should suffice, and the nurse in charge should be distinct from the ordinary staff of the Centre.

Apart from this, two or three rooms should be provided, communicating if possible. These would serve as waiting-room, weighing-room, and consultation-room. A shelter for prams is advisable. As a rule, not more than twenty-five to thirty cases, including not more than eight to twelve new cases, should be seen at one session. Infants should be examined every four to six weeks unless progress is unsatisfactory, while, after the age of two years, quarterly or half-yearly examinations are sufficient. Careful records must be kept of all mothers and infants.

Ante-natal work should, generally speaking, be done in the Centre on different days from infant work. Expectant mothers should be carefully examined, and, if necessary, pelvic measure-

ments should be taken. If the patient has engaged a private doctor for her confinement, no treatment should be undertaken at the Centre except at the request of the doctor in question.

7. **Provision for Confinements.**—Additional accommodation may be provided or arranged for by the Local Authority, and suitable charges fixed. In the event of a mother not being able or willing to leave her home for her confinement on account of her family, arrangements may be made for the children to be boarded out for a time. In other cases a **home-help** may be supplied to look after the house under the direction of the nurse or midwife. Such helps may be suitably trained at a Centre in plain cooking, mending, infant care, etc.

8. **Food.**—Milk and food may be supplied by the Local Authority to expectant and nursing mothers and to young children, at fixed charges. Under the Milk (Mothers and Children) Order, 1919, the following amounts of milk may be supplied on the certificate of the M.O.H. or the M.O. of a Child Welfare Centre—

Infants under eighteen months, not more than 1½ pints daily.
Children between eighteen months and five years, not more than 1 pint daily.
Expectant and nursing mothers, the quantity prescribed by the M.O.

Supplies may be given not only in necessitous cases, but also where such supplies are considered necessary on account of the high local price of milk. " Milk " includes any preparation of milk.

9. **Hospitals for Infants.**—Grants are available for provision of beds for children up to five years of age. This does not apply to cases of ordinary infectious disease, save ophthalmia neonatorum and epidemic diarrhœa.

10. **Crèches and Day Nurseries** may be provided for the children of mothers who go out to work.

11. **Convalescent Homes.**—Accommodation may be obtained for women after confinement, and for children convalescent from measles and whooping-cough.

12. **Illegitimate Children.**—Grants are available for homes where the mother and child may be kept together for the first year. In other cases, foster-mothers may be provided, or the mother herself may be assisted to remain at home and attend to her child.

The L.G.B. may pay grants, not exceeding one-half of the approved net annual expenditure, to Local Authorities and to Voluntary Agencies in respect of the following services—

1. The salaries and expenses of Inspectors of Midwives.
2. The salaries and expenses of Health Visitors and Nurses engaged in Maternity and Child Welfare work.
3. The provision of a midwife for necessitous women in confinement, and for areas which are insufficiently supplied with this service.

4. The provision, for necessitous women, of a doctor for illness connected with pregnancy, and for aid during the period of confinement for mother and child.

5. The expenses of a Centre, *i.e.* an institution providing any or all of the following activities: medical supervision and advice for expectant and nursing mothers, and for children under five years of age, and medical treatment at the Centre for cases needing it.

6. Arrangements for instruction in the general hygiene of maternity and childhood.

7. Hospital treatment provided or contracted for by Local Authorities for complicated cases of confinement or complications arising after parturition, or for cases in which a woman to be confined suffers from illness or deformity, or for cases of women who, in the opinion of the M.O.H., cannot with safety be confined in their homes, or such other provision for securing proper conditions for the confinement of necessitous women as may be approved by the M.O.H.

8. Hospital treatment provided or contracted for by Local Authorities for children under five years of age found to need in-patient treatment.

9. The cost of food provided for expectant mothers and nursing mothers and for children under five years of age, where such provision is certified by the M.O. of the Centre or by the M.O.H. to be necessary, and where the case is necessitous.

10. Expenses of crèches and day nurseries and of other arrangements for attending to the health of children under five years of age whose mothers go out to work.

11. The provision of accommodation in convalescent homes for nursing mothers, and for children under five years of age.

12. The provision of homes and other arrangements for attending to the health of children under five years of age, of widowed, deserted, and unmarried mothers.

13. Experimental work for the health of expectant and nursing mothers and of infants and children under five years of age carried out by Local Authorities or voluntary agencies, with the approval of the Board.

14. Contributions by the Local Authority to voluntary institutions and agencies approved under the scheme.

Grants will be paid to voluntary agencies aided by the Board on condition—

1. That the work of the agency is approved by the Board and co-ordinated as far as practicable with the public health work of the Local Authority and the school medical service of the Local Education Authority.

2. That the premises and work of the institution are subject to inspection by any of the Board's officers or inspectors.

3. That records of the work done by the agency are kept to the satisfaction of the Board.

SCHOOL HYGIENE

The principal legal measures affecting the school child are—

1. **The Elementary Education Acts,** which require the attendance at school of all children between the ages of five and fourteen years.

2. **The Elementary Education (Blind and Deaf Children) Act, 1893,** and the **Elementary Education (Defective and Epileptic Children) Act, 1899,** which require such children to be educated up to the age of sixteen years.

3. **The Factory and Workshops Act, 1901,** dealing with the employment of children of school age in factories and workshops (children under twelve years not to be employed in or about mines or factories; between twelve and fourteen years, children may be employed only on half-days or alternate days; under sixteen years, children must be certified as physically fit before being employed in factories).

4. **The Education (Provision of Meals) Acts, 1906** and **1914,** empowering Local Authorities to provide meals for elementary school children, both during school terms and at other times when the schools are not open.

5. **The Education (Administration Provisions) Act, 1907,** which made compulsory the medical inspection of school children, and gave powers to Local Authorities to arrange for the treatment of any defects found. This Act also gave power to provide means of recreation in schools, playgrounds, etc., during holiday times.

6. **The Children Act, 1908,** which gives the Local Authorities the right to cleanse verminous elementary school children.

7. **The Mental Deficiency Act, 1913,** under which the Local Education Authority must ascertain what children within its own district are defective within the meaning of the Act, and which of such children are incapable of being educated in special schools.

8. **The Education (Defective and Epileptic Children) Act, 1914,** which places on Local Authorities the duty of providing instruction for educable mentally defective children.

9. **The Education Act, 1918.** This is the most important measure of recent years. It contains the following provisions which modify much of the foregoing legislation—

(*a*) *Medical Inspection and Treatment.*—1. Adequate and suitable arrangements *must* be made for the treatment of elementary school children.

2. Boys and girls under the age of eighteen years attending secondary schools, continuation schools, etc., *must* be medically inspected on admission and at such other times as may be prescribed by the Board of Education. Treatment may also be provided for any defects found.

3. Prosecutions may be undertaken under the Children Act, 1908, by the Local Education Authority in cases of persistent neglect of children (such neglect includes failure to provide adequate food, clothing, lodging, or medical aid).

(*b*) *Physical Training, etc.* — Physical training *must* be included in the curriculum of continuation schools, and holiday camps, physical training centres, playing-fields, swimming-baths, etc., may be provided.

(*c*) *Special Schools.*—Local Education Authorities *must* ascertain what children in their area are physically defective or epileptic, and *must* make suitable provision for their education between the ages of seven and sixteen years.

(*d*) *School Attendance and Employment of Children.*—1. All children must attend school till the age of fourteen years, and a Local Authority may make a bye-law raising this age to fifteen (with the approval of the Board).

2. Children under twelve years must not be employed, and children over twelve must not be employed for more than two hours on Sundays, before the close of school hours on school days, or on any day before 6 a.m. or after 8 p.m. The Local Authority may make bye-laws allowing restricted employment before 9 a.m. and in the afternoon.

3. Street trading by any child under fourteen years is prohibited, and employment of children under the Factory Acts, or Acts relating to mines, is forbidden.

4. If it is certified by the school M.O., or otherwise, that any child is suffering in health, or is being rendered unfit to obtain proper benefit from its education, as a result of employment, such employment may be prohibited or restricted. An Authority has power to obtain particulars of a child's employment from his parent or employer.

5. Penalties are imposed on persons who employ children in contravention of this Act.

6. Young persons under the age of eighteen must attend a continuation school for not less than 320 hours a year. Employment must be suspended to allow of this. Provision is made for the gradual coming into operation of this section.

(*e*) *Nursery Schools.*—Local Education Authorities may establish anew, or aid existing, nursery schools intended for children over two and under five years of age, whose attendance at such a school is necessary or desirable for their healthy physical and mental development.

The Central Authority in matters of education is the Board of Education. Local Education Authorities deal with the various districts, and the medical work is carried on in individual schools, clinics, etc., by the school M.O. and the school nurse.

Duties of a School Medical Officer.—The school M.O. was first recognised in the Code of Regulations for Public Elementary Schools, 1908, as an officer having specific functions in the system of public elementary education.

His duties are—

1. To report on the working and effect of any arrangements made for educating children at open-air schools, school camps,

or other places selected with a view to the improvement of the health and physical condition of the children.

2. To advise or approve school closure.

3. To authorise the exclusion of certain children from school.

The Board of Education desires to concentrate and organise in the department of the school M.O. all matters of school hygiene, including medical inspection under the Act of 1907. It is for this reason that the M.O.H. and school M.O. are frequently one and the same official.

Other matters he must advise on are—

1. Suitability of school premises.
2. Effect of desks and benches on posture.
3. Eyestrain as affected by lighting, size of type in school books, fine sewing, etc.
4. Schemes of physical exercises with special regard to weakly children.
5. Personal hygiene.
6. Mentally and physically defective children.
7. Provision of school meals.

When he himself is not the M.O.H. of the district he must co-operate with the Sanitary Authority, and give all information possible regarding cleanliness, necessity for disinfection, prevalence of infectious disease, etc. Finally he is expected to advise parents regarding the advisability of obtaining treatment for any defects discovered in the children.

The school M.O. must report annually to the Local Education Authority, and two copies of the report must be sent to the Board of Education. If the M.O.H. is also school M.O., this report is included in his ordinary annual report.

The report should deal with the following matters—

(*a*) General conditions of school premises from the health standpoint.

(*b*) Methods of medical inspection adopted.

(*c*) Extent and scope of medical inspection.

(*d*) Conditions revealed by inspection.

(*e*) Means of treatment available.

(*f*) Infectious disease, and methods of prevention and detection.

(*g*) Physically and mentally defective children.

(*h*) Instruction in personal hygiene, physical exercises, open-air schools, etc.

Medical Inspection of School Children.—Not less than three inspections should be made during the school life of a child: (*a*) shortly after admission ("entrants"), (*b*) between the ages of eight and nine years, and (*c*) shortly before leaving ("leavers"). Defective children require more frequent inspection.

The accompanying schedule, as issued in Circular 582 of the Board of Education, constitutes the minimum of efficient medical inspection. It is intended as a guide to Local Authorities.

SCHEDULE OF MEDICAL INSPECTION

I.—Name ______________ Date of Birth [1] ______________

Address ______________ School ______________

II.—Personal History—

(*a*) Previous Illnesses of Child (before admission).

Measles.	Whooping Cough.	Chickenpox.	Scarlet Fever.	Diphtheria.	Other Illnesses.[2]

(*b*) Family Medical History (if exceptional).[3]

—	I.	II.	III.	IV.	—	I.	II.	III.	IV.
1. Date of Inspection					13. Ear disease [15]				
2. Standard and Regularity of Attendance [4]					14. Hearing [16]				
3. Age of Child [5]					15. Speech [17]				
4. Clothing and footgear [6]					16. Mental condition [18]				
[III.—*General Conditions.*]					[V.—*Disease or Deformity.*] [19]				
5. Height [7]					17. Heart and circulation [20]				
6. Weight [8]					18. Lungs [21]				
7. Nutrition [9]					19. Nervous system [22]				
8. Cleanliness and condition of skin[10]					20. Tuberculosis [23]				
Head					21. Rickets [24]				
Body					22. Deformities, Spinal Disease, etc.[25]				
[IV.—*Special Conditions.*]					23. Infectious or contagious disease [26]				
9. Teeth [11]					24. Other disease or defect [27]				
10. Nose and throat [12]									
Tonsils									
Adenoids									
Submaxillary and cervical glands									
11. External eye disease [13]									
12. Vision [14]									
R.					Medical Officer's initials				
L.									

General Observations.

Directions to Parent or Teacher.

NOTES FOR INSPECTING OFFICER

Ref. No.

1. Date of birth to be stated exactly, date of month and year.
2. "Other illnesses" should include any other serious disorder which must be taken into account as affecting, directly or indirectly, the health of the child in after-life, *e. g.* rheumatism, tuberculosis, congenital syphilis, small-pox, enteric fever, meningitis, fits, mumps, etc. The effects of these, if still traceable, should be recorded.
3. State if any cases of, or deaths from, phthisis, etc., in family.
4. Note backwardness.
5. Age to be stated in years and months, thus, $5\frac{4}{12}$.
6. Insufficiency, need of repair, and uncleanliness should be recorded (good, average, bad).
7. Without boots, standing erect with feet together, and the weight thrown on heels and not on toes or outside of feet.
8. Without boots, otherwise ordinary indoor clothes.

   Height and weight may be recorded in English measures if preferred. In annual report, however, the final averages should be recorded in both English and metric measures.
9. General nutrition as distinct from muscular development or physique as such. State whether good, normal, below normal, or bad. Under-nourishment is the point to determine. Appearance of skin and hair, expression, and redness or pallor of mucous membrane are among the indications.
10. Cleanliness may be stated generally as clean, somewhat dirty, dirty. It must be judged for head and body separately. The skin of the body should be examined for cleanliness, vermin, etc.; and the hair for scurf, nits, vermin, or sores. At the same time ringworm and other skin diseases should be looked for.
11. General condition and cleanliness of temporary and permanent teeth, and amount of decay. Exceptional features, such as Hutchinsonian teeth, should be noted. Oral sepsis.
12. The presence or absence of obstruction in the naso-pharynx is the chief point to note. Observation should include mouth-breathing; inflammation, enlargement, or suppuration of tonsils; probable or obvious presence of adenoids, polypi; specific or other nasal discharge, catarrh, malformation (palate), etc.
13. Including blepharitis, conjunctivitis, diseases of cornea and lens, muscular defects (squints, nystagmus, twitchings), etc.
14. To be tested by Snellen's Test Types at 20 feet distance (= 6 metres). Result to be recorded in the usual way, *e. g.* normal V. = $\frac{6}{6}$. Examination of each eye (R. and L.) should, as a rule, be undertaken separately. If the V. be worse than $\frac{6}{9}$, or if there be signs of eye strain or headache, fuller examination should be made subsequently. *Omit vision testing of children under six years of age.*
15. Including suppuration, obstruction, etc.
16. If hearing be abnormal, or such as interferes with class work, subsequent examination of each ear should be undertaken separately. *Apply tests only in general way in case of children under six years of age.*
17. Including defects of articulation, lisping, stammering, etc.
18. Including attention, response, signs of overstrain, etc.

    The general intelligence may be recorded under the following heads: (*a*) Bright, fair, dull, backward; (*b*) mentally defective; (*c*) imbecile. *Omit testing mental capacity of children under six years of age.*
19. Under the following headings should be inserted particulars of diseased conditions actually present or signs of incipient disease. The extent of this part of the inspection will largely depend upon the findings under previous headings.

20. Include heart sounds, position of apex beat, anæmia, etc., in case of anything abnormal or requiring modification of school conditions or exercises.
21. Including physical and clinical signs and symptoms.
22. Including chorea, epilepsy, paralyses and nervous strains and disorders.
23. Glandular, osseous, pulmonary, or other forms.
24. State particular form, especially in younger children.
25. Including defects and deformities of head, trunk, limbs. Spinal curvature, bone disease, deformed chest, shortened limbs, etc.
26. Including any present infectious, parasitical or contagious disease, or any sequelæ existing. At each inspection the occurrence of any such diseases since last inspection should be noted.
27. Any weakness, defect or disease not included above (*e.g.* ruptures) specially unfitting child for ordinary school life or physical drill, or requiring either exemption from special branches of instruction or particular supervision.

Vision may be considered as bad when the child can read only $\frac{6}{18}$ (Snellen) at a distance of 20 feet. Hypermetropia is common in younger children, myopia in older. Astigmatism is a common cause of headache. Squint is often associated with hypermetropia, and a squinting eye in time may become blind through lack of use. Bad school arrangements are responsible for a good deal of eyestrain—*e. g.* insufficient light, light from a wrong direction, badly lit blackboards, fine sewing, and too small print in textbooks. Bad home conditions, of course, render the child more prone to suffer.

Hearing should be tested by forced expiratory whisper at a distance of 20 feet. Each ear must be examined separately.

The following table is a return affecting upwards of 100,000 children examined in 1914—

Physical condition, etc.	Percentage of defective "leavers" in		
	14 industrial areas.	15 residental areas.	11 rural areas.
Clothing (unsuitable or insufficient)	7·6	3·8	1·4
Uncleanliness of head	21·2	13·7	8·3
Uncleanliness of body	7·8	4·1	3·8
Malnutrition	13·2	11·7	8·9
Diseases of nose and throat	18·1	17·3	15·7
External eye disease	1·9	2·0	1·9
Defective vision	30·5	29·1	19·2
Disease of ears	2·2	2·4	1·4
Defective hearing	2·8	4·2	1·9
Dental caries	79·7	67·6	66·5
Diseases of heart and circulation	8·0	5·9	2·6
Disease of lungs	3·8	1·6	1·0

In 1917 Dr. C. J. Thomas carried out a model inspection of 300 London school children and 273 country school children.

All classes of children at the "leaver" age were examined, and the results are given in the accompanying Table (Annual Report for 1917 of the Chief Medical Officer of the Board of Education).

STATISTICAL RESULT OF TYPICAL INSPECTION

Conditions.	London. Total.	Country. Total.	London and country. Total.
	Per cent.	Per cent.	Per cent.
Nutrition—			
(1) Good	40·7	40·0	40·4
(2) Fair	48·0	46·7	47·5
(3) and (4) Poor	11·3	13·3	12·1
Cleanliness—			
Head—			
(1) Clean	67·8	70·9	68·9
(2) Unsatisfactory (nits)	30·0	20·6	26·5
(3) Bad (verminous)	2·2	8·5	4·6
Body—			
(1) Clean	69·2	80·0	73·3
(2) Unsatisfactory (dirty)	22·0	14·5	19·2
(3) Bad (verminous)	8·8	5·5	7·5
Teeth—			
(1) Good	60·0	35·1	50·7
(2) Caries (slight)	35·2	56·4	43·1
(3) Caries (severe)	4·8	8·5	6·2
Nose and throat	5·5	21·2	11·4
External eye disease	4·4	1·8	3·4
Vision—			
(1) Better than $\frac{6}{12}$ both eyes	72·9	81·2	76·0
(2) $\frac{6}{12}$ both eyes or $\frac{6}{12}$ one eye and better than $\frac{6}{12}$ in the other	15·0	11·5	13·7
(3) $\frac{6}{12}$ in one eye and worse in the other, or worse than $\frac{6}{12}$ in both eyes	12·1	7·3	10·3
Ear disease	5·5	1·8	4·1
Hearing—			
(1) ¾ normal and upwards	79·9	92·8	84·7
(2) ½ to ¾ normal	12·1	3·6	8·9
(3) Less than ½ normal	8·1	3·6	6·4
Speech Defect	1·8	1·2	1·6
Heart—			
Valvular Disease	0·7	1·2	0·9
Other Defects	4·4	2·4	3·7
Lungs Defective	1·8	3·6	2·5
Rickets	2·2	1·2	1·8
Enlarged Thyroid	2·6	7·9	4·6
Deformities	2·6	1·2	2·1
Anæmia, Pronounced	8·4	3·6	6·6
Spinal Curvature, Pronounced	5·1	3·6	4·6
Flat Foot	8·4	3·6	6·6
Skin Disease	6·2	1·8	4·6
Syphilis	0·4	—	0·2

Dr. Thomas points out that "upwards of one-third of all these elder children, most of whom possessed some degree of physical defect, and 21% of whom were seriously defective, are, in London at least, two or more years behind their normal school standard. Physical defect is one of the chief causes of backwardness in school."

Treatment of School Children.—From 20–30% of children inspected on a routine basis require treatment.

General Requirements.—(*a*) Healthy way of living, (*b*) proper feeding—if necessary under the Education (Provision of Meals) Acts, (*c*) adequate supply of fresh air, (*d*) exercise of the body by effective methods of physical training, (*e*) suitable clothing, (*f*) sufficient rest by day and by night, (*g*) cleanliness.

Treatment Scheme.—(Medical Officer's Report, 1917, Board of Education.)

1. An adequate scheme of medical inspection and diagnosis.
2. An adequate system of school nursing.
3. Establishment of school clinics (medical, surgical and dental).
4. Arrangements with hospitals for treatment of school children, when the private practitioner and the school clinic are unavailable or inappropriate.
5. The supply of spectacles, gratuitously or at a reduced rate.
6. Remedial treatment centres for physical deformities.
7. Special schools or classes for blind, deaf, dumb, feeble-minded, epileptic, tuberculous, crippled or debilitated children requiring institutional treatment.

Under the Education (Administrative Provisions) Act, 1907, the Local Education Authority has power to make such arrangements as may be sanctioned by the Board of Education for attending to the health and physical condition of the children educated in public elementary schools. The 1918 Education Act makes this compulsory.

Arrangements are made usually for the following—

(*a*) Treatment of minor ailments.
(*b*) Operative treatment of enlarged tonsils and adenoids.
(*c*) Dental treatment.
(*d*) Treatment of visual defects and the provision of spectacles.
(*e*) X-ray treatment of ringworm.

The *school clinic* serves two purposes: (1) Medical inspection of special cases, and (2) treatment centre.

The size and equipment of a clinic vary enormously. There should be a waiting-room, consulting-rooms, minor-ailment treatment-room, dental-room, operating theatre, X-ray room, and lavatories. Provision should be made for dealing with infectious cases, and, if necessary, a small laboratory could be included. Accommodation for clerks and nurses is necessary.

The clinic should be the centre of the whole system of school hygiene in the district. In spite of the arrangements made by many Local Authorities, "about one-third of the defective children go untreated in the more favoured areas, whilst in others the majority are untreated."

Provision of Meals.—The Education (Provision of Meals) Acts, 1906 and 1914, enable Local Education Authorities to provide meals not only during school hours, but also during holidays. They may be provided gratuitously in necessitous cases, or on payment of a stipulated sum. Circular No. 856 of August 15, 1914, contains a memorandum on methods of providing such meals and an appendix with notes on dietary and tables of meals.

Physical Education.—The Medical Department of the Board of Education bases a national scheme of physical education on the following—

(*a*) A syllabus of physical education for all elementary schools, by means of which reasonable uniformity may be secured. A combination of Swedish exercises with games, dancing, etc., appears most suitable.

(*b*) Training in physical exercises for all students attending elementary training colleges, as well as special holiday courses, etc., for teachers.

(*c*) Appointment of expert gymnastic teachers to act as inspectors or local organisers.

(*d*) Reasonable facilities (including sufficient time) and equipment for games, play, dancing, swimming, as well as for the more formal gymnastic exercises.

It is advised that a daily lesson of not less than twenty minutes should be given. Organised games should also be arranged.

The exercises should be taken if possible in a properly ventilated playground shed. Class-rooms are unsatisfactory. Assistance should be given to the scholars to provide shoes, and cheap and simple tunics can be made by the girls in their needlework classes. Folk and country dances are being more and more taught to girls with good results. Evening play-centres are increasing in number. At present they are confined to children attending school. The school premises are used for table games and useful occupations of all sorts. Organised games are also played in the playground. Paid helpers are necessary, and voluntary assistance is desirable. Instruction in swimming is becoming more universal. In certain instances the Local Education Authority have provided special baths. In most cases arrangements are made for the admission of the children to public baths at special times. In any case it is advisable to provide school shower-baths in districts where children are unable to have suitable bathing in their own homes.

Juvenile Employment.—Under the Employment of Children

Act, 1903,[1] bye-laws may be made by local authorities to regulate the conditions under which children will be allowed to work. Sufficient use has not been made of this power. It is estimated that from 10–12% of the children between ten and fourteen years of age living in towns are employed. The M.O. of the Board of Education suggests that all School M.O.'s should undertake definite duties with regard to premature or excessive employment of children—

1. To report periodically on the employment of all children of school age, and its effect on their health.
2. To examine all "leavers" with regard to their fitness for employment.
3. To examine employed children as "specials," and certify the authority if they are suffering in health or being rendered unfit to obtain full benefit from their education.
4. To secure rapid treatment for such children where necessary.
5. To co-operate with the certifying factory surgeon of the district in selecting children for factory work.
6. To furnish (on application) the Welfare Supervisor of factories and workshops, where the child is employed, with the latest school medical report on the child's physique.
7. To co-operate in every way with the Juvenile Employment Committee or with the Labour Exchanges, and to aid in carrying out the provisions of the Employment of Children Act.

Infectious Disease.—Infectious diseases are spread either by the sick child itself in the early stages, by mild or abortive cases, or by carriers. In investigating any outbreak of disease, a M.O. should examine especially carefully all children attending the school from the same street or neighbourhood as the recognised patients, all children in the same class, and especially those who have returned to school after a short absence due to some undiagnosed complaint. The infant school is the most commonly affected. Measles and whooping-cough are much less fatal diseases after the age of five years, and the mortality rates for scarlet fever and diphtheria are also greater below five years. Much can be done by avoiding overcrowding in such schools, and by attending to their general hygiene.

A memorandum on closure of, and exclusion from, school was issued in 1909. It deals largely with infectious disease and points out that in the course of time an infectious disease history will be available for each child, which will help greatly in dealing with the problem.

Exclusion of Individual Children.—All children suffering from infectious disease must, of course, be excluded till they have ceased to be infectious, and till disinfection has been carried out.

[1] More extensive powers are granted under the Education Act, 1918. See p. 137.

It is often necessary, too, to exclude all children from an infected house or street, and those who have been in contact with a case of infectious disease. These latter may be allowed to return to school after a period, slightly longer than the maximum time of incubation of the disease, has elapsed, provided they present no abnormal symptoms.

It is important to remember that Sec. 58 of the P.H.A. (A) A., 1907, if adopted, enables lists of scholars in a school, in which any scholar is suffering from an infectious disease, to be obtained.

School Closure may be necessary (1) on account of sickness in the teacher's family, involving risk to the scholars, (2) for disinfection and cleansing after an outbreak of infectious disease, (3) to rectify any sanitary defects. Otherwise, if exclusion of individual children be wisely undertaken, it should very rarely be necessary to close a school. School closure is more likely to be of use in the country than in towns, as in the former case children have fewer chances of mixing when out of school. Closure of a department or a single class may be necessary at times, and this does not constitute "school closure," as understood in the code. If it should be decided to close a school to prevent spread of disease, it is advisable to close the playground and to endeavour to obtain the closure of Sunday Schools as well.

How a School is closed or individual Children excluded under the Code of Regulations for Public Elementary Schools—

(*a*) *Article* 57 *of the Code.*—If the Sanitary Authority or any two members thereof, acting on the advice of the M.O.H., require closure of a school or a department, or the exclusion of certain children for a specified time, with a view to preventing the spread of disease or any danger to health likely to arise from the condition of the school, such requirement must at once be complied with.

(*b*) *Article* 45*b*.—Grants [1] will still be paid when schools are compulsorily closed under Article 57, **or under the advice, or with the approval of the school M.O.,** or for any other unavoidable cause.

(*c*) *Article* 53.—The school M.O. may exclude certain children, to prevent the spread of disease, or if they are in an unclean or verminous state, or if, on account of physical or mental defects, they cannot receive proper benefit from instruction in school.

The school M.O. gives a certificate to this effect, and a copy must be sent to the Local Education Authority.

These provisions practically mean that school closure and exclusion of children must be approved by the school M.O., and this necessitates close co-operation between that official

[1] Under the 1918 Act grants are not dependent to the same extent upon average attendances as compared with the number on the roll.

and the M.O.H., if he is not one and the same person. By such co-operation it will seldom be necessary to apply to the "Sanitary Authority or two members thereof," as mentioned in Article 57. Copies of all certificates should be sent by one officer to the other, and both should be notified by head teachers, nurses, and attendance officers of any suspected children temporarily excluded. In London it is compulsory on the M.O.H. to send a copy of each notification certificate, within twelve hours of its receipt, to the head teacher of the school attended by the patient or by any child coming from the same house. This procedure is advised in all sanitary districts.

If the Sanitary Authority close a public elementary school, the reason should be stated, a definite time should be specified, and a copy of the notice should be sent to the School M.O. The period of closure specified should be as short as possible, for a second notice may be sent before the expiration of the first. A report of a M.O.H. to his Sanitary Authority advising closure is to be regarded as a special report, and copies of it must be sent to the L.G.B. and the County Council. If the school M.O. excludes children, he must give a certificate, a copy of which must be sent to the Local Education Authority.

In **Scarlet Fever** the patient should not attend school till two weeks after his return from hospital, or till two weeks after complete disinfection if he has been nursed at home. Children in the same house must not attend school in either case till two weeks after disinfection has been done. School closure is rarely necessary, as the disease spreads slowly, and a careful search for slight cases and children with discharges should help to limit the outbreak.

In **Diphtheria** the patient should not return to school till at least two weeks (often four) after discharge from hospital. Discharge from hospital should not take effect till three successive negative swabs have been obtained on different days, with at least forty-eight hours interval from the time of the last application of disinfectant to the throat; so, too, if the child is nursed at home. Children from the same house should be kept at home for two weeks after removal of the case. It is advisable to make a bacteriological examination of their throats. As diphtheria causes many deaths in young children, it is frequently advisable during an epidemic to exclude all children under school age.[1] Modern methods of diagnosis should make it unnecessary to close more than single classes of older childern.

In **Measles** infected children should be excluded for at least four weeks. Only children from the same household who have not had the disease should be excluded—for twenty-one days from the date of sickening of the case. Classes may be closed

[1] In certain districts children under 5 years are admitted to Infant Departments.

on the ninth day after the onset of illness in the first case, for a period of five days. After this period only those who have meantime fallen ill, or those from the same household who have not had measles, or those who attend the infant school, need be excluded. Warnings to parents advising them to keep at home any child showing signs of a " cold " are a useful measure.

In **Whooping-cough** the child must be excluded till all cough has disappeared. Children in the household attending the infant school must be excluded for the same period.

In **Mumps** three weeks isolation. It is not necessary to exclude contacts.

In **Chicken-pox** isolate till all scabs have disappeared—usually about three weeks. Exclude from the infant school any members of the same household.

SPECIAL GROUPS OF CHILDREN

1. **The Nervous Child** has an excitable nervous system and may suffer from habit spasm, headache, and, later on, more definite functional disturbances, such as hysteria. It should be taught in a special class, and preferably in an open-air school.

2. **The Backward Child.**—(*a*) Backward but intelligent—due frequently to some illness which has prevented school attendance, or some defect such as slight deafness.

(*b*) Backward and dull—mostly inborn, and not remediable. A certain proportion, however, suffer from defects such as adenoids, errors of vision, general delicacy, and poor nutrition. Under skilled attention considerable improvement may be noted. Such a child should be taught in a special class, and manual work should bulk largely in the time-table.

3. **The Mentally Deficient Child.**—The Mental Deficiency Act, 1913, defines the three main groups as follows—

(*a*) **Feeble-minded Persons** are those in whose case there exists, from birth or from an early age, mental defectiveness not amounting to imbecility, yet so pronounced that they require care, supervision and control for their own protection, or for the protection of others, or, in the case of children, that they, by reason of such defectiveness, appear to be *permanently* incapable of receiving proper benefit from the instruction in ordinary schools.

(*b*) **Imbeciles** are persons in whose case there exists from birth, or from an early age, mental defectiveness not amounting to idiocy, yet so pronounced that they are incapable of managing themselves or their affairs, or, in the case of children, of being taught to do so.

(*c*) **Idiots** are persons so deeply defective in mind from birth, or from an early age, as to be unable to guard themselves against common physical dangers.

"Moral imbeciles" are those who, from an early age, display some *permanent* mental defect coupled with strong vicious or criminal propensities, on which punishment has had little or no deterrent effect.

Tredgold has estimated that feeble-minded children form about 8·3 per 1000 of an average school population, while imbeciles and idiots amount to about 0·73 and 0·25 respectively per 1000 of the general population. Heredity, syphilis and alcoholism are important factors in the etiology. Diagnosis of the condition and correct classification of the child are not easy. All physical defects, such as deafness, must be carefully excluded, and attention should be directed to the following points: Muscular balance, habits such as spitting and lack of control of sphincters, speech, response, concentration, moral character, and educational attainments. The tests of Binet and Simon are of considerable use in estimating the degree of intelligence of such children.

Treatment.—Power to establish special schools is given under the Elementary Education (Defective and Epileptic Children) Act, 1899.

A Royal Commission in 1906 estimated the number of feeble-minded children in England and Wales at more than 35,000. At the present moment there is not day-school accommodation for more than one-half of such children.

Under the Mental Deficiency (Notification of Children) Regulations, 1914, issued by the Board of Education, the school M.O. and any other M.O. appointed by the Board of Education are considered as certifying officers. It is their duty to certify any child of seven years and upwards, incapable, by reason of mental defect, of receiving benefit from instruction in a special class or school. The Local Education Authority must then notify the name and address of such child to the Local Authority [1] under the Mental Deficiency Act, 1913. In cases of doubt, this matter should be referred to the Board of Education. Provision is made under the Mental Deficiency Act for sending such children to special institutions, or placing them under guardianship.

Day Special Schools.—These may be placed in the outskirts of large towns. The children will probably have to be conveyed to school either by tramcar or special ambulance. Meals will have to be provided, and a large part of the instruction should be purely practical.

Homes and Colonies are more satisfactory. Farm work and other useful trades may be taught the boys, while the girls can learn to do a good deal of useful housework. Imbecile and idiot children should be so accommodated, except when the home conditions are exceptionally good.

[1] The County Council.

4. **The Epileptic Child.**—If the fits occur as a rule during school hours, the child is usually excluded from school. Should, however, the attacks come on at night, the child may attend school. For epileptics who are either mentally deficient or insane, special provision should be made in homes or colonies.

5. **The Blind Child.**—Ophthalmia neonatorum accounts for some 30% of all blind and partially blind children. Keratitis and corneal ulceration are also common causes. Education is provided for them in special day schools, and, better still, residential schools. High myopia (inability to read $\frac{6}{60}$) necessitates instruction in a special class. The Elementary Education (Blind and Deaf Children) Act, 1893, requires arrangements to be made both for these and the following group of children.

6. **The Deaf Child.**—If the child is only hard of hearing it can be taught in a small special class. Deaf and deaf-mute children should be sent to special day or residential schools. "A child is hard of hearing who cannot hear, with at least one ear, the forced whisper at a distance of 6 feet, but can hear it at 3 feet." Deaf-mutism is congenital in about one-half of the cases, and meningitis, measles, and scarlet fever account for the majority of the remainder.

7. **The Physically Defective Child.**—There is a tendency to confine this term to "cripple" children. If the word "cripple" is used at all, it should refer to a child suffering from any physical defect whatever. Such defective children have been found to derive considerable benefit from open-air education. Open-air class-rooms, and classes in playgrounds and public parks, are suitable for children with minor defects such as catarrhal conditions, anæmia, etc. For children suffering from defects of greater degree special day open-air schools have been established in a good many districts, and even open-air residential schools are advocated. These latter are really hospitals where children can receive proper nursing attention.

Day Open-air Schools should be placed as near the homes of the children as possible, and yet in the country. Provision has to be made for conveyance of the children to and from the school.

The site should be open, but sheltered. The structure should be as simple as is compatible with comfort all the year round, and it is possible at times to make an existing building the nucleus of the school. Shelters should be supplied. Ample floor space (at least 20 square feet per child) is necessary, and the classes should not exceed about twenty-five. The total number of children in any school should not be more than 120. Couches and rugs must be provided for use during rest hours. There should be single desks or tables and chairs, and light folding furniture for use out-of-doors. Lessons should occupy a minimum of one and a half hours morning and afternoon, about two hours rest should be allowed for in the middle of the day, and

the remainder of the time may be filled in by physical exercises, breathing exercises, walks in the neighbourhood, etc. The children must be warmly clad, and three meals a day should be arranged for. Shower-baths are advisable.

The defects most commonly found in children sent to such schools are enlarged cervical glands, anæmia, enlarged tonsils and adenoids, and lung diseases (but not open tuberculosis). Convalescents after diseases such as pneumonia or surgical operations, and badly-nourished children, with poor home conditions, benefit greatly. In certain instances children may be allowed to spend the night in the school premises if their homes are very unsatisfactory. In the majority of the children their general health improves greatly, their weight and chest measurement increase markedly, and as a rule the child is able to rejoin its class with no loss of time after its attendance at the special school. Many children require to attend several months, and some should receive the whole of their education in such schools.

In 1917 there were thirty-one open-air schools in England and Wales, with accommodation for over 2000 scholars. There are also sanatorium schools in various areas for children affected with pulmonary or surgical tuberculosis. After-care committees have been appointed in many districts to look after the future welfare of all defective children, especially the feeble-minded.

The School Premises (see Building Regulations for Public Elementary Schools, Cd. 7516, 1914).

The Site should be central and easy of access. About a quarter of an acre for every 200 children will be found necessary. If at all possible a field or public park should adjoin. The best aspect is S.E. The building should be at least 60 feet from a street, and about 20 square feet of playground should be allowed per child.

The Building may be either of the central hall type or pavilion type. In the former case, rooms open directly into the hall on at least three sides; in the latter, the rooms open into verandahs, and the hall is quite separate. The central hall type is unsatisfactory. Free cross ventilation is impossible, direct sunlight is not obtainable in all the rooms, and undue noise and dust may disturb the adjoining rooms. The only advantages to be claimed for it are that it is more compact, more easily supervised and somewhat cheaper. The pavilion type, on the other hand, enables all rooms to have their proper share of ventilation and sunlight.

If possible there should be no more than two storeys, corridors should be from 6–8 feet wide, and staircases at least 4 feet wide, with a doorway opening outwards at the bottom. Every part of the building should be as fireproof as possible.

The floor space per child, as laid down for elementary schools, need only be 10 square feet (9 square feet for children under

seven). Fifteen square feet would be a better standard, but as sixty children are allowed in many classes, this would render existing accommodation quite inadequate. It must be remembered in planning class-rooms that floor space is of more importance than cubic space. 1500–1800 cubic feet of fresh air per head per hour are recommended.

Class-rooms should be not less than 12 feet high, a clear space extending the full width of the room of not less than 7 feet 6 inches in depth should be left for the teacher, and there should be 1 foot of space between the last row of desks and the wall, and a gangway of not less than 1 foot 4 inches on one side of each child.

The hall should have a floor space of about 3½ square feet for each scholar, provided the total area does not exceed 1500 square feet. If no hall is provided, arrangements should be made to throw two or three class-rooms together when required.

Walls and floors should be as dustproof and easily cleansed as possible. Floors should be level throughout.

Ventilation.—Artificial ventilation is to be avoided where possible. The Plenum system has been introduced in certain schools, but the air has a devitalising effect on the scholars, and the constantly closed windows constitute a bad object lesson. Satisfactory ventilation can usually be secured by natural means. Windows should be placed on opposite sides of the room, and all should be made to open, if possible, into the external air. One of the best types of windows has the lower pane arranged to open inwards as a hopper inlet with side pieces, the upper part of the window being hung on its centre to swing, in order to give as large an opening as possible. There should be ample means of flushing the class-room with fresh air at the end of every lesson. Windows should extend nearly to the ceiling.

Lighting.—Natural lighting should be provided by windows, the proportion of glass to floor area being as 1 is to 5. The lower glass line of the main windows should not be more than 3 feet 6 inches above the floor, while the tops should reach nearly to the ceiling. Heavy mullions should be avoided. The main light should come from the left, as fewer inconvenient shadows will be cast. Too brilliant a light may be avoided by means of sun blinds. Electric light is the best form of artificial lighting. Illuminating coal gas with incandescent burners is the next best. For ordinary class work, a minimum standard of 2-foot candles is required, for fine work 4-foot candles. There must be no glare; suitable shades, ground glass bulbs, etc., secure this. Blackboards should be well lighted, and have a dull surface.

Warming.—A temperature of from 56–60° F. should be maintained in the class-rooms, and in the infant school the tem-

perature should always be about 60° F. The rooms and their furnishings should be properly warmed before the children arrive. The best method to employ is hot water at low or medium pressure, with coils of piping or radiators in each class-room. Not less than 30 square feet of heating surface will be required per 1000 cubic feet. A little more will be necessary in infant rooms, and in rooms at the end of the system. Closed stoves are not good. Ventilating fire-places are satisfactory in smaller rooms. Ventilating radiators are sometimes used, fresh air being admitted through the wall behind the radiator, which is fitted with a metal plate to direct the cold air upwards. By this means air is warmed somewhat before it passes into the room. The method is better in theory than in practice.

Seats and Desks.—Single seats and desks are best, dual seats are next best. Continuous desks with single seats are not so good, but are better than continuous seats and desks. Single seats and desks are best, as each child can be accommodated with the size that is most suitable for him, and, in addition, the spread of infectious disease and verminous conditions may be hindered. Desks and seats require adjustment every term, otherwise errors of posture may arise. Suitable tables and chairs are often provided in infant schools.

The requirements of a good seat and desk are—

1. The seat should hold two-thirds of the thigh, the front edge should be rounded, and the height from the seat to the floor should be such that, when the child's feet are resting on the ground, the leg is vertical and the thigh horizontal.
2. There should be a back-rest suitably curved to the body, reaching to the level of the shoulder-blades.
3. The desk should be vertically distant from the seat one-sixth of the height of the scholar, and the edge of the writing surface should be almost directly over the edge of the seat (a slight overlap is better than a gap). There should be a slope of about 8° for writing, and a flat surface should be obtainable.

Cloak-rooms should be separated from the rest of the building by cross-ventilated passages. They must be well ventilated, lighted and warmed. Each child should have its own peg, and the pegs should be well spaced, so that hats, etc., do not touch (12 inches apart for boys and 18 inches for girls). The pegs are usually fastened on both sides of a stand, in which case there should be a partition of fine wire netting. The floor should be impervious, and glazed tiles to a height of 5 feet are advisable. Drying-rooms may be provided adjoining the cloak-rooms.

Lavatories may adjoin cloak-rooms. There are usually far too few basins—at least two for every fifty children should be provided, with a proper proportion of clean towels. Hot and

cold water should be supplied. All drinking-water cups should be kept in running water, and frequently cleansed.

Closets, etc., are better placed in the playground. If not, they must be in a suitable sanitary annexe connected with the main building by a cross-ventilated corridor. Water-closets are, of course, the best provision, with a separate flush for each seat. There must be separate accommodation for the older boys and girls, and each closet must have a door.

Approximate number of closets—

	Girls.	Boys.
Under 30 children	3	1
50 ,,	4	2
70 ,,	5	2
100 ,,	6	3
150 ,,	8	3
200 ,,	10	4
300 ,,	14	5
400 ,,	18	6

Ten feet of urinal should be allowed for every hundred boys.

Playgrounds must be separate for boys and girls. About 20 square feet for each child will be advisable, and the surface should be paved, in part, at any rate, to provide an area suitable for physical exercises in wet weather. For the same reason shelters should be supplied. Roof playgrounds are satisfactory in crowded districts.

Disposal of Excreta and Waste Waters in Country Districts.—When a water supply is available for flushing but there are no sewers, water-closets should be drained into a water-tight tank with an overflow discharging on to an efficient filter or a suitable area of land for irrigation, or into a water-tight cesspool without overflow. Rain-water should be excluded in either case.

Where neither sewers nor water service are available, some form of dry closet will be necessary. Pails or small fixed receptacles are allowed, and some suitable absorbent, such as earth, ashes or sawdust, will be needed. Waste waters may be taken by drains to a filter or irrigation area, or into a small cesspool. It may be necessary in certain instances to use movable receptacles for the reception of waste liquids, in which case the receptacle for urine should be filled with sawdust.

Rain-water from roofs should be collected for washing purposes.

SECTION VII

CONTROL AND PREVENTION OF DISEASE, INDUSTRIAL DISEASES, NOTES ON ANIMAL PARASITES, ETC., HOSPITALS, DISINFECTION

THE CONTROL AND PREVENTION OF DISEASE

INFECTIOUS disease may be localised in one district or country; a case occurs from time to time and the infection never seems to disappear. Such a disease is said to be endemic, and the infection is handed on from one case to another, probably by means of carriers. Endemicity may be influenced by climatic conditions and soil, *e. g.* malaria, and also by the habits and social conditions of the people. Should the infection be communicated to a large number of persons more or less simultaneously, an epidemic results. A disease becomes pandemic when it spreads over the surface of the globe, as in the case of influenza in 1918.

Epidemiology is the study of the periodicity of disease. Much attention has been paid during the last thirty years to the study of epidemics, and endeavours have been made, by referring to past history, to foretell the probable course of future outbreaks. Statistical evidence has been available only since the beginning of last century, and so far, on account of the multiplicity of agencies at work, the problem is still in the process of elucidation. " Epidemics, however, occur with sufficient regularity to suggest that laws descriptive of them may ultimately be propounded. It is impossible to predict the course of any given epidemic without careful consideration of the previous history of the disease in the country under consideration and in the world at large."

Epidemic waves have been drawn from the mortality rates of certain infectious diseases. These waves show three types of rise—

1. A broad, undulating wave whose crests attain their maxima at intervals of many years or even centuries.
2. Smaller crests superimposed on the large wave at intervals of years.
3. Still smaller rises depending mainly on seasonal prevalence and occurring at intervals of months.

Factors influencing the epidemic wave—

1. **Alteration in Virulence of the Causal Agent.**—This is thought by many to be responsible for the gradual rise and fall in the major waves. It spells an " alteration in type " of the disease, and includes an alteration in potency of superadded secondary infections as well, *e. g.* faucial involvement in scarlet fever. The rise of the wave is marked by an increasing severity of attack and a greater degree of infectivity—the more severe the case the more infectious, as a rule. During inter-epidemic periods the disease is less infectious, and it is thought to be this increase in infectivity that determines the epidemic. It is well established that the beginning and end of many epidemics may be marked by very mild, almost unrecognisable, cases. Another variation in type may be observed, in that a certain disease may show a tendency to attack individuals at a later age. Thus scarlet fever now is not a common disease amongst young children till opportunities of infection are multiplied, as at school.

2. **Gradual Accumulation of Susceptible Persons.**—This may act over longer or shorter periods. A disease may have a selective influence whereby the more susceptible individuals are attacked first, with the result that a relatively immune population is created. The disease dies down and the opportunities of contracting it grow less and less, with the result that the proportion of susceptible persons again increases, and the way is prepared for a fresh outbreak. On the other hand, it has been noted that epidemics have tended to decline long before the susceptibles have been exhausted by death or recovery. This would suggest that a more probable reason is a diminution of the infective power of the causal agent. The age and sex constitution of a population may have some influence. It has, however, been argued that the periodicity of a disease influences the age distribution of those dying from it. Thus, when small-pox used to occur every four or five years, the bulk of the deaths were below five years. When epidemics occurred at greater intervals the average age of those dying was proportionately raised, but here the influence of vaccination must have played a large part. So, too, with the exception of diphtheria and whooping-cough, more males die from infectious disease than females, even though females may show a greater number of attacks.

3. **Environment.**—(*a*) Climatic and soil conditions play a part. Temperature especially is important. It may render more active the growth of the causal organism or, on the other hand, during cold spells may assist the spread of infection by inducing collections of people in ill-ventilated rooms. The seasonal prevalence of disease appears to have a definite relationship with temperature. The seasonal maximum of attacks does not always mean a proportionate increase in the mortality. Hence the smaller annual rises in the waves may imply less fatal attacks. At

times, however, as the seasonal curve falls, the relative proportion of deaths may show a certain increase. The temperature of the earth, as recorded by the 4-foot earth thermometer, has been shown by Ballard to be positively correlated with the summer diarrhœa curve.

(*b*) Social conditions, such as greater urbanisation, with accompanying poverty and insanitary surroundings, all help. The overcrowding of young children in schools gives greater opportunity for the spread of disease. On the other hand, any improvement in the housing and working conditions and general social status of a population tends to increase resistance to infection. A pure water supply and improved general sanitation markedly reduce the incidence of typhoid fever and allied diseases.

(*c*) Human interference with the actual epidemic—earlier diagnosis, better isolation, improved treatment, prophylactic measures, such as vaccination—exercises a certain influence. This influence, however, acts more in the direction of controlling an epidemic once it has started than in actually preventing its occurrence or altering its form. Thus, small-pox among the unvaccinated in 1902 was of much the same type as that prevalent in the eighteenth century.

In scarlet fever the crest of the mortality wave was reached between 1860 and 1870. Well-marked minor waves occur every five or six years, while the seasonal rise appears as a maximum in October and November. Whitelegge maintained that, "when the scarlet fever mortality curve rises at regular intervals, it does so for two reasons: (1) because the attacks are more numerous, and (2) because they are more fatal in type. They are numerous because the infective agent becomes more virulent, and more able to attack less susceptible people, and because the severer cases are more infectious in themselves. In addition, with the spread of the disease there is more opportunity of getting infected, and there are more susceptible people to infect on account of their comparative freedom from infection during the trough of the wave." Scarlet fever is becoming a declining disease, both as regards numbers attacked and case mortality, and with the decline there is a tendency to irregularity or disappearance of regular waves. There is thus a tendency to change of type.

In small-pox the trough of the major wave was seen in 1850–1860. Slight epidemics occurred every four or five years after that with increasing magnitude till 1871, when the crest was reached. Then came a gradual fall, but still with slight rises every four or five years, till 1885, when the disease seemed to disappear. Outbursts were recorded in 1892 and 1901–1902. Of recent years there appears to be a tendency to prevalence every nine years. The seasonal wave reaches its height in the first half of the year. Vaccination, however, has had a very disturbing action on the periodicity of small-pox.

In measles, wave-crests appeared between 1830 and 1835, between 1840 and 1845, between 1860 and 1870, and between 1880 and 1890. Minor waves occur at intervals of two or three years, and seasonal prevalence shows two maxima, one in June and the other in December. The minor waves are apt to be explosive in character. Measles is altering very little in type—it is just as severe now as it was twenty or thirty years ago.

In diphtheria a rise was noted between 1860 and 1864. A decline followed, but another rise occurred between 1883 and 1893. There is some evidence of minor waves about every five years, with seasonal prevalence in the last quarter. The disease is becoming somewhat less severe, but not to the same extent as scarlet fever. (Milroy Lectures, Whitelegge, 1893. Greenwood, "The Factors that Determine the Rise, Spread and Degree of Severity of Epidemic Diseases," 17th International Congress of Medicine, London, 1913.)

AVERAGE DEATH-RATES IN THE METROPOLITAN ASYLUMS' BOARD'S HOSPITALS IN QUINQUENNIAL PERIODS

(*M.A.B. Annual Report*, 1918)

	1872–6	1877–81	1882–6	1887–91	1892–6	1897–1901	1902–6	1907–11	1912–16	1917	1918
(I) Scarlet fever	12·4	12·6	10·7	8·3	5·5	3·5	3·1	2·5	1·6	1·9	1·8
(II) Diphtheria	—	—	—	33·6	25·5	13·7	9·3	8·8	7·1	6·7	7·7
(III) Enteric fever	18·6	20·0	17·5	15·3	17·5	15·6	14·6	14·6	16·3	17·3	13·4
(IV) Typhus fever	21·2	21·1	18·9	17·2	15·3	15·3	14·0	—	42·1	—	—
(V) Cerebro-spinal fever	—	—	—	—	—	—	—	45·5	44·7	53·6	63·9
(VI) Measles	—	—	—	—	—	—	—	13·8	10·5	11·7	13·2
(VII) Whooping-cough	—	—	—	—	—	—	—	11·6	10·2	13·4	17·5

RATES IN SMALL-POX EPIDEMICS

	1870–2	1876–8	1879–83	1884–5	1893–4	1901–2
(VIII) Small-pox	18·8	18·2	16·5	15·9	8·0	16·8

Scarlet Fever is a disease of temperate climes. It is more prevalent in towns, especially industrial centres, than in the country. Its causal agent is unknown, but streptococcal complications are common. The incubation period varies from one to five days; the rash appears on the first day; isolation should be practised for six weeks, or until all desquammation or discharges have ceased, with quarantine of contacts for seven days. Seasonal prevalence is most marked in the last quarter of the year (October and November), and the incidence is almost

in inverse ratio to the rainfall. The greatest attack rate is in the fifth year, but the mortality rate is highest in the first and second years. Many persons never contract the disease, and if a child can be protected in its early years, it will be less susceptible to attack later on, and less likely to die should it become infected. Females are more liable to attack, but more fatal attacks occur in males. The patient is infectious from the very beginning of the symptoms till the cessation of desquammation and of all discharges from nose, ears, etc. Fomites may also spread the infection. Epidemics have been traced to milk supply, but infection has most likely been introduced by a human carrier, as it is not generally accepted that scarlet fever is a disease to which cows are liable. Missed cases of very mild type are probably the most important cause of spread of the disease. The case mortality is from 1–2%.

The epidemiology has been dealt with on p. 157. The disease is assuming a milder form, but the prevalence is not diminishing to the same extent as the mortality.

Return cases have been defined by the Society of Medical Officers of Health as "cases occurring in the same house or elsewhere, and apparently traceable to the person released within a period of not less than twenty-four hours, or not more than twenty-eight days, after his return or release from isolation." Such cases are more common in scarlet fever than in any other infectious disease. They form from 2–3·5% of all convalescents discharged. Discharges from the ears and nose have been found in many of the infecting cases, and it has been noted that scarlet fever convalescents may become infectious only after contracting a catarrh. Return cases are most numerous when fever hospitals are full, really during epidemics, and this may be attributed either to a greater tendency of the disease to spread or to overcrowding in the hospitals with resulting relaxation of the regulations. It is possible that the incidence may be lowered by more stringent isolation of the severe cases of scarlet fever and segregation of all patients under fresh-air conditions for the last two weeks of convalescence. Thorough cleansing of the child must be practised before discharge from hospital. As a general rule in scarlet fever chronic carriers are unknown. Out of a "total of 1573 return outbreaks investigated there were 1176 of scarlet fever after scarlet fever, 168 of diphtheria after diphtheria, 101 of diphtheria after scarlet fever, and forty-four of scarlet fever after diphtheria. Cases of both scarlet fever and diphtheria followed the discharge of a scarlet fever patient in twelve instances, and the discharge of a diphtheria patient in five instances." More infecting cases came from the acute wards than from the convalescent, and most were patients who had been detained for fairly long periods in hospital (eight to twelve weeks).

It is the practice in many districts to isolate, so far as possible, every case of scarlet fever. It is doubtful, in view of the present mild type of the disease, if the removal to hospital of all cases is worth the expense or is advisable on public health grounds. Many cases are unrecognised, and the isolation of others is thus rendered less useful. In addition, before removal is carried out, the patients have usually been ill for some little time. It is inadvisable, especially during times of epidemic prevalence, when hospitals may become so overcrowded as to be actually dangerous to the health of the inmates. In no case should beds be reserved for scarlet fever cases to the exclusion of more serious diseases, such as diphtheria or enteric fever. On the other hand, severe and complicated cases require hospital treatment, inasmuch as proper nursing is likely to improve their chances of recovery, and as they themselves are more likely to spread infection. Again, cases should not be left at home, where their remaining might cause public alarm, as in post offices, laundries, dairies, etc., or where pecuniary loss might be incurred, as in hotels or boarding-houses, more particularly in health resorts. Local circumstances must determine the amount of hospital accommodation to be provided.

Small-pox (Variola) is a disease whose causal agent is unknown. It may occur in any part of the globe, but tends to be endemic in the Soudan and Arabia.

The incubation period is usually twelve days (ten to fourteen); the rash appears on the third day; isolation should last till all scabs have separated (usually three to four weeks), with quarantine of contacts for fifteen days. Seasonal prevalence is most marked in the first half of the year, with a maximum at the end of May. In tropical climates, however, it is most marked in the cool season. The winter prevalence of small-pox in this country may be due to the congregation of the poorer classes within-doors at this season, for it is almost invariably among the poorer classes that small-pox first breaks out. The periodicity has been noted on p. 157, and it must be remembered that, though less prevalent than formerly, the disease has not altered much in type. Any age may suffer, but both incidence and mortality fall mainly on the unvaccinated. Males show a higher mortality rate than females. The case mortality is greatest in infancy and least between ten and fifteen years. It increases again with age. Vaccination has greatly influenced the mortality —thus between 1847 and 1853, when vaccination was optional, the death-rate per thousand was 0·305; between 1854 and 1871, when vaccination was not thoroughly carried out, the rate was 0·223; between 1872 and 1891 it was 0·009, and in the last decennium it was practically nothing. Improved sanitary and social conditions must, of course, have exercised a considerable influence as well. Small-pox may be spread by the breath, by

personal emanations, and by fomites. Mild, unrecognised cases, especially among vaccinated persons, are liable to spread the disease, the condition frequently being mistaken for chicken-pox. Though mild in themselves, such cases may cause very severe infection. Tramps and vagrants generally are one of the main sources of danger. Much discussion has raged round the possibility of aerial convection since Power's report on the incidence of small-pox in the neighbourhood of Fulham Hospital in 1881. Parsons summed up the evidence for and against as follows (Isolation Hospitals, Cambridge, P.H. Series, 1914)—

For.—Excessive incidence has frequently been noted around hospitals where many acute cases are collected. This incidence has been graduated according to the distance from the hospital, and is greatest when the number of acute cases under treatment is rapidly increasing. The disuse of a hospital, with the substituted use of another, has led to a transference of small-pox prevalence from the neighbourhood of the former to that of the latter. The excessive incidence in the neighbourhood of the hospital cannot be explained by personal communication incidental to the working of the hospital or by leakages owing to defects in the working, as it has persisted when such communications have been reduced to a minimum and safeguarded in every way. Ordinary communications do not spread infection from a hospital in which the cases are few or convalescent. In many of the cases within the special zone no communication, direct or indirect, with the hospital can be discovered. In Purfleet (a village on the opposite bank of the Thames to the hospital ships) the spread of small-pox followed the direction of the prevailing wind.

Against.—The more obvious explanation may be found in direct or mediate infection conveyed by personal communications, such as ambulance journeys, visits of friends to patients, visits by nurses off duty, calls of tradesmen and workmen, staff residing off the premises, leakages of various kinds, as well as by contacts and missed cases. Such communications would be more numerous with houses situated near the hospital, and would be more frequent when the hospital was full, and the regulations consequently liable to be strained. It is at such times that spread of small-pox around a hospital has occurred. If one case within the special area round the hospital can be accounted for by personal communication, the inference is that other cases can as well. Inquiries are conducted some time after the event, when many of the circumstances may have been forgotten, and, furthermore, nurses and employees are not likely to give themselves away by owning to carelessness. Small-pox has not always shown marked prevalence round small-pox hospitals, and at Liverpool there was an apparent special incidence round a hospital not used for small-pox. At all events, the incidence

is marked only at epidemic times, when the disease has a natural tendency to spread. Modern ideas tend to discredit aerial infection, as seen in our change of views regarding the spread of influenza and diphtheria.

Whichever view is the correct one, the practical conclusion arrived at is that small-pox hospitals are not now erected in the midst of towns, but are removed as far as possible from populous places.

Isolation should invariably be practised. The disease is very infectious, it is dangerous and disfiguring, and the public dread it. Patients bear removal well, and, if the sick person is out of the way, contacts can be dealt with by vaccination or revaccination. When the patient recovers he is no longer infectious, and cleansing of contacts and disinfection of their belongings and homes soon stamp out the disease.

In the event of a case of small-pox occurring in a district, the patient should forthwith be removed to hospital and the house and his belongings thoroughly disinfected. Contacts should be vaccinated and quarantined, or preferably examined by a Medical Officer daily for fourteen days. Chicken-pox should be made notifiable if small-pox shows signs of beginning to spread, and the service of an expert diagnostician made available in the district. The movements of all tramps and vagrants should be carefully watched, and if possible such persons should be submitted to medical inspection.

Vaccination was introduced by Jenner in 1798, when he successfully inoculated human beings with cow-pox material. Prior to this, inoculation with actual small-pox virus had been practised fairly extensively. In 1840 vaccination was provided for all who cared to benefit, and in 1853 it became compulsory. In 1871 Boards of Guardians had to appoint Public Vaccinators. Formerly arm-to-arm inoculation was practised, but now only glycerinated calf lymph is employed. The process of manufacture in the Government laboratories is as follows: Thoroughly healthy calves are aseptically vaccinated on the abdomen with lymph. Five days later the vesicles are scraped off and the mass, after being thoroughly pounded, is mixed with six times its weight of sterile 50% glycerine in distilled water. It is then stored for about one month till no growth on agar is obtained from it. It is issued in capillary tubes, and remains active for about fifty days. A more rapid method used elsewhere is to sterilise the lymph by treating it with chloroform vapour.

In this country there is no power to re-vaccinate, save in the case of individuals joining certain services, such as the Army, Navy, police force, nursing institutions, etc. In France re-vaccination is compulsory between the ages of ten and eleven and twenty and twenty-one; so, too, in Germany. Thorough vaccinations means three or four marks, each half an inch square. In a

typical course a vesicle develops about the fifth day and is mature on the eighth. A scab begins to form on the tenth day and separates about the twentieth. In re-vaccination the vesicle frequently appears at an earlier date. As the incubation period of vaccination is shorter than that of small-pox, a person successfully vaccinated within three days of exposure to infection may escape altogether, or have only a mild form of attack.

The results of efficient vaccination are: The chances of contracting small-pox are much lessened and, should the disease occur, it will be milder in type, with a lowered case mortality. The attack rate is five times as great in the unvaccinated as in the vaccinated, while under ten it is fifteen times as great. The case mortality in the unvaccinated is about 35%, while in those showing four or more marks it is only about 1%. In those with fewer marks the mortality is correspondingly greater, but even in cases having only one mark it amounts to only 6–7%. Figures for institutions and services show that re-vaccinated persons usually escape altogether during epidemics, while the unvaccinated succumb. In Germany before the War small-pox was almost unknown, and any fatal cases that did occur were found among unvaccinated children. In this country the number of deaths under fifteen years has been markedly reduced since vaccination became compulsory. After that age the reduction is not so marked. This tends to prove the effect of vaccination, as this alteration in age incidence is not marked in any other disease. This alteration in age incidence, too, is a reply to the argument that the lower mortality rate is due to improved sanitation and social conditions.

Various injurious results have been attributed to vaccination, such as syphilis, erysipelas and cancer. There has probably been little or no foundation for any of these allegations, even in the past, when arm-to-arm inoculation was the practice. Nowadays, with the universal employment of sterile calf-lymph, the operation, if asepsis is maintained, can cause no harm whatever to the child. It has been argued that vaccination results in a large number of mild and modified cases which help to spread the disease in a partially vaccinated community. But a number of modified cases occur even in the unvaccinated, and any increase in the number of these is more than counterbalanced by the protection undoubtedly afforded to the bulk of the vaccinated.

Vaccinia or cow-pox. Klein and Copeman in 1892 succeeded in inoculating a calf with small-pox material and in passing it through three other calves. The lymph from the fourth calf produced typical vaccinia in a child. Copeman maintained in consequence that vaccinia in the calf is really small-pox modified by passage through an animal of another species.

Diphtheria is a disease of temperate climates. It was formerly more common in rural than in urban districts, but in the last

quarter of the nineteenth century it showed a tendency to increased death-rate in large towns. This death-rate is, however, decreasing again. Diphtheria appears to be somewhat more prevalent in cold and wet districts, and in some parts of the country it is practically endemic. Epidemic waves occurred in 1860–1864 and again in 1883–1893. There is some evidence of minor waves every five years. The disease is somewhat less severe than formerly.

The causal agent is the Klebs-Lœffler bacillus. The incubation period is from one to seven days, usually two to four. Isolation should be practised till bacteriological examination of the throat and nose on three different days has yielded negative results, care being taken that no disinfectants have been applied to the throat within the previous forty-eight hours. In addition, any discharges present must have ceased. Contacts should be isolated till negative swabs are obtained from their throats.

Children under thirteen suffer most, and the mortality is greatest at three or four years. After thirteen years the mortality declines. This incidence at school age was first noticed when the Elementary Education Act came into force in 1871. During school holidays the prevalence is less. Females show a higher mortality than males. Seasonal prevalence is most marked in the last quarter of the year and is lowest in the middle third. The case mortality is under 8% in all cases admitted to the M.A.B. fever hospitals. In pre-antitoxin days it amounted to 30%. The earlier antitoxin is given in the disease, the less likely is diphtheria to prove fatal. In cases treated on the first day the mortality is only 3·3%, on the second day 6·5%, on the third day 10·6%, on the fourth day 12·9%, and on the fifth and subsequent days 14·8%. That paralysis may occur a little more frequently in cases treated with antitoxin is probably due to the fact that more cases so treated survive.

Diphtheria is not highly infectious, and fairly close contact is usually necessary for the spread of the disease. The bacilli may remain virulent for three to four weeks when dried, and fomites may thus prove a source of danger. Missed cases and those carrying the organism in their throats, noses or ear discharges, are the common centres of infection. Many of these carriers have suffered from an actual attack, while others may yield virulent organisms without ever having shown symptoms (bacteriological diphtheria). The organisms persist for varying lengths of time in the throats of the patients. Thus in 85% of cases they disappear within one week of the clearing up of the false membrane, while after four weeks, as a rule, none can be found. Infective nasal discharges are specially apt to be missed, and many outbreaks in school classes have been traced to such an origin. Return cases are, however, much less numerous than in scarlet fever (see p. 159). Considerable numbers of children carry in

their throats organisms indistinguishable from true Klebs-Lœffler bacilli—as many as 10% during epidemic periods. All these organisms are not virulent on injection into guinea-pigs, but all must be considered potentially dangerous. Any condition tending to lower the vitality of the throat renders individuals more liable to contract diphtheria. Milk has been considered the medium of infection in certain cases (L.G.B. Report, New Series, No. 94, 1914), but diphtheria is not a disease from which the cow can suffer. Lower animals, such as pigeons and other birds, cats and horses, are said to be attacked at times, but it is doubtful if such conditions are communicable to man. Post-scarlatinal diphtheria is well recognised, and is probably due to the introduction of a diphtheria carrier into a scarlet fever ward.

As diphtheria cases require skilled nursing and treatment, it is advisable to isolate as many as possible in fever hospitals. Preventive measures include the immediate isolation of the case for the period already indicated. Careful examination of the throat, nose and ears must be made before discharge. It is well to advise that the child should not mix with other children for another period of two weeks after his return home. The throats of all contacts should be examined bacteriologically, more particularly if schools, barracks, etc., are under consideration. All individuals showing positive results should be excluded and treated till free. Preventive inoculation—500–1000 units of antitoxin—has been advocated, but it is not largely practised, principally on the score of possible anaphylaxis resulting in an individual subsequently receiving a large treatment dose of antitoxin. Antitoxin should be kept by Local Authorities to be issued free to such cases as may require it for treatment.

It has been suggested that the Shick test might be used as a means of determining those persons likely to contract diphtheria during epidemic prevalence. In individuals not naturally immune the intra-dermic injection of 0·2 c.c. ($\frac{1}{50}$ M.L.D) of toxin produces a local reaction about 25 mm. in diameter in twenty-four to twenty-eight hours.

Measles (Morbilli) occurs both in temperate and tropical countries. The causal agent is unknown; the incubation period varies from ten to fourteen days (usually ten); the rash appears on the fourth day; isolation lasts for three weeks, or till all complications and discharges have ceased, and quarantine of contacts for twenty-one days. Epidemic waves have been noted in 1815, 1840–1845, 1860–1865, 1882–1889 and 1896. Lesser waves appear usually every two years, but occasionally every three, and last, as a rule, only for a few months. These minor waves may be due to accumulation of susceptible persons with special opportunities for infection in schools. Seasonal prevalence shows two maxima, one from November–January, and the other from

April–June. Over 90% of the deaths occur in children under five. The mortality is greatest in the second year of life and diminishes markedly after five years. Both sexes are equally affected, and adults, if not protected by a previous attack, are susceptible. The fatal results are usually attributable to broncho-pneumonia or other pulmonary complications, due in the majority of instances to streptococcal infection, probably from septic conditions of the mouth and naso-pharynx. Infection is spread mainly during the early catarrhal stage, when diagnosis is uncertain. The contagion may attach itself to fomites, but is short-lived.

The mortality of all cases treated in the M.A.B. was 11·7% in 1917, while the death-rate per thousand of the population was 0·41 in the same year. As a rule, in epidemics the case mortality falls between 1·4 and 4%. "In the three years 1911–1913, 33,457 deaths in England and Wales were caused by measles at ages under five, and at the same ages 83,650 by bronchitis and pneumonia, which in many instances are the terminal stage of an attack of measles (or of whooping-cough), which is not mentioned in the death certificate. It is noteworthy also that during the same three years all the notifiable diseases (small-pox, scarlet fever, diphtheria, enteric fever, puerperal fever and erysipelas) were responsible for only 31,641 deaths at all ages, as compared with 36,627 from measles. On an average about 11,000 deaths from measles occur every year in England and Wales." In addition measles is frequently the cause of prolonged disablement, that makes its effects felt all through life.

Notification of measles and German measles was introduced in 1915 (Measles and German Measles Order). Each case or suspected case had to be notified by the parent or guardian to the M.O.H., and a medical practitioner had to notify the first case seen by him in a given household, if this case or a previous case in the same household had not already been notified by the parent, and if no case of the same disease had been notified in the same household within two months. The practical value of notification depends on the extent of the measures available for preventing the spread of infection and for diminishing the mortality from the disease. Each case should be regarded as a means of discovering other cases. As no doctor is in attendance in a large proportion of the cases, the Order imposed on the M.O.H. the duty of seeing that all necessary inquiries regarding diagnosis were made either by himself or by some practitioner acting under his instructions. The domestic isolation and treatment, including the nursing of patients, needs supervision, and provision should be made for the reception of a certain number of cases in an isolation hospital. (Notification ceased December 31, 1919, under the Rescission Order, 1919.)

About 75% of all London elementary school children have

suffered from measles, and spread of the disease may be expected in any class containing over 30% of children not protected by a previous attack. If a sickness record is kept of all children attending elementary schools, it will be an easy matter during a measles epidemic to exclude all those who have not already had the disease (see p. 147). School closure for measles has not justified itself in the past, largely on account of the multiple opportunities of infection, other than schools, afforded in large towns. As most of the cases will have to be treated at home, the Sanitary Authority can help by means of health visitors and nurses, employed either directly or through a nursing association. It is usually advisable to divert temporarily from other work health visitors, sanitary inspectors and any available nurses employed by the Sanitary Authority. The poorest families should be attended first, and especially those in which children from one to four years are suffering from measles or have been exposed to infection. Leaflets of advice regarding measles may be distributed to parents as an auxiliary to personal advice and assistance. (See L.G.B. memorandum on Measles, November 1915.)

Rubella (Rose measles, German measles) is a mild disease made notifiable in 1915, as it is frequently confused with true measles. The incubation period is eleven to eighteen days, the rash appears on the first day, isolation is maintained for three weeks, and quarantine of contacts for twenty-one days. (Notification ceased December 31, 1919, under the Rescission Order, 1919.)

Whooping-cough (Pertussis) is a disease mainly of temperate climates. Epidemics occur at irregular intervals, and seasonal prevalence is greatest in March and April. The incubation period is from five to fourteen days, isolation lasts till two weeks after the last whoop, and quarantine of contacts for fifteen days. The causal agent is the Bacillus pertussis. Some 90% of the deaths occur under five years, and nearly half in the first year. The case mortality in the M.A.B. in 1918 was as high as 17·5%, but the number of cases treated was small, and probably only those seriously ill were admitted. The death-rate per thousand of the population was 0·42 in 1918. As in measles, most of the deaths are due to broncho-pneumonia directly attributable to lack of proper attention at home. The disease is not notifiable, and the fact that infants under one year suffer so seriously makes the question of hospital treatment particularly difficult.

Chicken-pox (Varicella) is of consequence mainly on account of the fact that mild cases of small-pox are liable to be confused with it. Hence in times of small-pox prevalence chicken-pox is usually made notifiable. The incubation period is ten to sixteen days, vesicles appear on the first day, isolation lasts till the skin is quite clear, and quarantine of contacts for twenty-one days.

Mumps (Infective Parotitis) is apt to be more severe in adolescents and adults than in young children. The incubation period is from fourteen to twenty-two days, isolation lasts for three weeks and quarantine of contacts twenty-four days. It is most prevalent in spring and autumn. The causal agent is unknown.

Tuberculosis in all forms has shown a considerable decline since 1860. In England and Wales, phthisis alone has declined 50%, but in Ireland there has been a slight increase. This lessened incidence is more marked in females than in males. In 1854 one-seventh of all deaths were due to tubercular causes, in 1903 only one-ninth. In males the age of maximum mortality is now forty-five to fifty-five, in females thirty-five to forty-five; in both cases the age has been postponed. In 1917 the death-rate per thousand living was 1·624 for tuberculosis (all forms) and 1·135 for pulmonary tuberculosis. In a report to the Medical Research Committee (No. 18, 1918) Brownlee suggests that phthisis is a mixture of three allied conditions: (1) a young-adult type, with the commonest age at death between twenty and twenty-five years; (2) a middle-age type, with the commonest age at death between forty-five and fifty-one years; (3) an old-age type, with the commonest age at death between fifty-five and sixty-five years. He concludes that the young-adult type is not affected to any extent by environment, in this respect resembling scarlet fever, for it is as frequently met with in better-class localities as in poorer ones.

"The present epidemic of phthisis among the young had its maximum somewhere about the middle of last century, while the epidemic among the middle-aged had its maximum fully one hundred years ago. There is no doubt that a considerable part of the decline of phthisis in recent years is in line with the biological properties of diseases in general and has little to do with hygienic conditions. It has been argued that, because the mean age at death for phthisis has been steadily rising, the population has become more immune, either on the ground of elimination of the susceptible persons or on the ground of better hygienic conditions." Brownlee points out, however, that a rise in the mean age at death necessarily follows if the type of phthisis that is disappearing is that among young adults. In a Local Government Board Report (New Series, No. 88, 1914) it was pointed out that post-mortem examination of 195 children between two and ten years of age, dying from various causes, proved tuberculosis in 60·5%. This percentage included six cases in which living tubercle bacilli were demonstrated, although no actual lesion was detected. Over 60% of the children showing tuberculous lesions had died of this disease. These were, of course, all hospital cases, and the figures cannot be taken as representative of the state of affairs throughout the country

generally. Children under five years, however, afford more deaths from tuberculosis than any other quinquennium.

The tubercle bacillus found in man may be of either human or bovine type. The Royal Commission discovered that, of sixty cases investigated, 23% were of bovine type, and about half of these gave evidence of alimentary infection. In the L.G.B. Report quoted above, out of ninety-eight cases of children dying of tuberculosis between the ages of two and ten years, 82·7% showed bacilli of human type, and 18·4% bacilli of bovine type. In America, an analysis was made of 1511 cases collected from the literature of various countries, and the following table was published in the *Journal of Medical Research* (September 1912)—

	Percentage incidence of Bovine infection.		
	16 years and over.	5–16 years.	Under 5 years.
Pulmonary tuberculosis . .	0·4	0	2·8
Tuberculous adenitis cervical .	2·7	38	61
Abdominal tuberculosis . .	20	53	58
Generalised tuberculosis, alimentary origin	14	57	47
Generalised tuberculosis . .	0	16	8·6
Generalised tuberculosis, including meninges, alimentary origin .	0	0	66
Tubercular meningitis (with or without generalised lesions other than the preceding) . . .	0	0	4·6
Tuberculosis of bones and joints .	3·3	6·8	0
Tuberculosis of skin . . .	23	60	0

Among predisposing factors must be classed poverty, bad housing, dirt and alcoholism. Insufficient ventilation has been considered by several workers to be a potent cause, as evidenced by the statistics of back-to-back houses. Thus in Salford the phthisis death-rate was 5·2 per thousand where all houses were back-to-back, and only 2·8 where no such houses existed. It is probable, however, that lack of proper ventilation was only one of many causes in the instance quoted. A damp sub-soil appears to play a part, for the phthisis death-rate has been lowered in districts once efficient sub-soil drainage has been installed. Dusty trades, especially those dealing with siliceous material, are accompanied by high phthisis death-rates. The children of tubercular parents apparently inherit a susceptibility to the disease.

The bacilli may be inhaled, ingested or inoculated. In dust they may retain their vitality for considerable periods, hence a

child allowed to crawl about dirty floors and streets may conceivably become infected in this way. Over 10% of samples of milk in large towns have been shown to contain these organisms, and many samples of butter likewise. Pasteurisation of milk, unless carefully carried out, is not a safeguard, and even drying and condensing processes do not always kill the bacilli, though they tend to render them less virulent. Beef is frequently infected, and the tuberculous material may get smeared over the flesh during dressing of the carcase. The temperature reached during roasting is insufficient to kill tubercle bacilli in the centre of a joint of 6 lbs. or a roll of meat of 4 lbs.

Measures of Control.—Under the Public Health (Tuberculosis) Regulations, 1912, all cases of tuberculosis must be notified to the M.O.H. The information given must be considered confidential, and nothing must be done that will interfere in any way with the sufferer's livelihood. The Local Authority may appoint special officers to deal with the disease in their own area, and may supply medical and other assistance and all such facilities and articles as may reasonably be required.

Under the National Insurance Act, 1911, insured persons are entitled to "sanatorium benefit," which means treatment in institutions (other than Poor Law) or otherwise—this includes dispensaries. Of the fifteen pence set aside for every insured person, ninepence is available for this benefit, and the Insurance Committee of any county or county borough may extend such benefit to dependents. Tuberculosis dispensaries have been established in practically all areas. They are used as centres of diagnosis, treatment and "after-care," and for the examination of contacts. One dispensary is necessary for every 150,000–200,000 persons, and Treasury grants were made available for four-fifths of the initial cost, provided the total sum did not exceed £1 per 250 of the population or an average of £240 per dispensary. Under the scheme, sanatorium beds were to be made available in the proportion of 1 per 5000 of the population for treatment, and the same number for observation, training and isolation. Treasury grants may be obtained amounting to £90 per bed, or three-fifths of the total cost per bed.

A sanatorium should be placed on elevated ground, preferably on a southern slope, sheltered from the north and east. The site should not be too far from a railway station, but should not adjoin a main road. A sanatorium of not more than 100 beds is the ideal size, and about 100 acres of ground should be acquired. Single rooms, or wards containing not more than six beds, are best. There must always be a central administrative block with wards attached to it, but part of the accommodation may well be provided in single-bed shelters. Buildings made of good weather-boarding or corrugated iron lined internally and set on concrete platforms may be used. The idea, still prevalent

in certain quarters, that sanatorium treatment is synonymous with a good deal of discomfort should long ago have been dispelled. The Medical Research Committee published a Report on the mortality after sanatorium treatment (No. 33, 1919). It deals with 1053 men and 654 women. Of all cases discharged after a recognised period of treatment, males furnished 15·7 times and females 18·2 times the number of deaths that would have been expected in an average sample of the general population. When the disease was considered to be arrested, these figures were respectively 4·4 and 4·2, and, when the condition was only improved, 33·1 and 28·2.

For some time past "colonies" have been developed in connection with the treatment of consumption. These have been mainly "farm colonies," where an attempt has been made to train patients for work on the land. The tendency latterly has been to extend training to other trades, such as boot-making and repairing, basket-making, cabinet-making, carpentry, motor-driving, etc. As a general rule patients have been carefully selected, and only those likely to remain well have had the benefit. Government grants are available for such places as for sanatoria. Skilled instructors must be obtained, and classes of about sixteen form the minimum for their economical employment. The shortest apprenticeship for learning a skilled trade may be considered as nine to twelve months. Any work done by the patients is really part of their treatment, but a small wage paid is often a psychological aid to recovery. This should not prevent their receiving any disablement benefit to which they may be entitled. It has been proved at the farm colony near Edinburgh that the sale of produce meets about 50% of the total expenditure. An extension of these colonies is being attempted now, and it is suggested that other classes of patients should be admitted than have hitherto been dealt with. As so many men who do well in sanatoria have relapses within a short time of their resuming work, it would be advisable that part-time work should be given them in a colony as the final stage of their treatment. An ideal state of affairs would be the building up of a village for consumptives, where even chronic incurable cases would be admitted and retained for the rest of their lives. This scheme is actually being worked out at Papworth Hall in Cambridgeshire. Cottages must be built to accommodate whole families whose wage-earner is consumptive, single men can be housed in hostels, and a nursing-home must be provided for relapsed cases or those too ill to remain at home. Such a colony is best situated in the neighbourhood of a town, and the local Tuberculosis Officer might be put in charge.

Whatever scheme be adopted, none is complete without an efficient "After-care" Committee, whose business it is to look after the family while the father is undergoing treatment, and

to secure suitable work for the consumptive after his treatment has been completed (L.G.B. Report, New Series, No. 122, 1918).

Pneumonia.—The pneumococcus is the organism most commonly found in this condition. It is normally present in the mouths of many individuals, up to 80%, according to some observers. Association with a case of pneumococcal pneumonia will frequently result in the appearance of the pneumococcus in the mouth of a person previously free from it. It is stated that the virulence of the organism increases during the winter months in the same individual. The resistance of the pneumococcus is low. It dies after exposure for one and a half hours to sunlight, but in moist sputum in the dark it may live for ten days.

Pneumonia is more common in cities than in the country. It is a disease of both hot and cold countries, and is most prevalent in winter, mortality being greatest from January to March. Poverty, alcoholism and trauma are predisposing factors. The incidence falls heavily on those below six years, it then diminishes to fifteen, but increases for every year after that. In people over sixty-five the condition is a very serious one. Males are more affected than females. The death-rate among the civilian population of England and Wales in 1917 was 0·257 from lobar pneumonia, and 1·44 from all forms of pneumonia. Case mortality is heavy (15–25%). Negroes and natives generally in the tropics suffer severely from pneumonia. This was noted particularly in the native compounds of the Transvaal, and an investigation was begun by Sir Almroth Wright in 1911–1912. Prophylactic inoculation with pneumococcus vaccine was tried extensively, with excellent results, and later it was discovered that various types of pneumococcus could be differentiated serologically. Specific-group vaccines were used in consequence, with a still further decline in the death rate. The following table shows some of the results obtained—

	1911.	1912.	1913.
Population (daily average strength)	10,426	12,549	15,284
	Per cent.	Per cent.	Per cent.
Proportion of population inoculated	0·0	about 50	about 92
Incidence rate of pneumonia	4·0	1·28	0·74
Death-rate of pneumonia	0·97	0·31	0·14
Incidence rate of other diseases	31·0	20·7	14·4
Death-rate of other diseases	0·51	0·38	0·34

Some difficulty was experienced during the War in issuing the vaccine, but the annual death rate from pneumonia has steadily

fallen from 12 per 1000 (1908–1911) to 4 per 1000 in 1918. Since the pneumonia death-rate formerly represented over 40% of the general mortality, it follows that the general death-rate has sunk correspondingly.

In the European War prophylactic vaccination was used largely in the American Army. Three types of pneumococcus were employed, and several billions of each type were given in every dose. Three or four inoculations were made at intervals of five to seven days. Among the vaccinated troops (12,519) the pneumonia death-rate was 0·83 per 1000, whilst among the unvaccinated (20,000) it was 12·8. Severe local reaction was apt to occur with these large doses, so a "lipo-vaccine" was substituted, that is, a suspension of the pneumococci in an oily medium. Only slight local or general reaction follows the use of this method, even though enormous doses are given, the immunising response is greater, and only one inoculation is necessary. A dose of ten billions of each of the three types of pneumococcus (I, II, and III) resulted in practically no disturbance, and lowered considerably the incidence and case mortality among 13,460 men inoculated (*Lancet*, November 29, 1919, p. 983).

Influenza.—Pandemics of influenza occurred in 1837, 1847, 1890 and 1918–1919. It is possible that outbreaks of somewhat obscure disease, referred to in literature as far back as the sixteenth century, may really have been manifestations of this same condition. The rapidity of the spread is limited only by the speed of human travel and, like other diseases in which infection appears to enter through the respiratory passages, the progress is hardly stayed by any public health measures at our disposal. It enters a country by its ports or frontier towns. The causal agent is considered to be Pfeiffer's bacillus, inasmuch as it is frequently found in the respiratory tract of those suffering from the disease and rarely in persons who have not recently become convalescent from influenza. It has been discovered in the blood of some of the severe cases during epidemics, and it commonly occurs in the lesions of cases dying of complications, such as pneumonia (present in forty out of fifty-three cases at autopsy). The bacilli appear to multiply in the mucosa of the trachea and bronchi without at first producing excessive secretion, hence the difficulty experienced by many observers in finding these organisms. Serum tests so far have not given any very conclusive results (*B.M.J.*, 1918, II., p. 505). It is possible that, while Pfeiffer's bacillus is the actual causal agent of influenza, the fatal complications that so often ensue are due to superadded infections with pneumococci, hæmolytic streptococci and other organisms. It is always noted that during epidemics of influenza the death-rate from respiratory diseases generally shows a marked increase. In normal times acute respiratory diseases are responsible for one-sixth of the deaths

from all causes, and even in years in which influenza is epidemic they cause several times as many deaths as this disease. From 1915–1918 there was a close correspondence between the curves of cerebro-spinal fever, pneumonia and influenza in the British Army. The same winter and spring conditions favoured each. Brownlee has pointed out that epidemics of influenza appear to have their maxima from the beginning of January to the end of May and that, when one epidemic follows another, an interval of thirty-three weeks usually intervenes. An analysis of the London figures from 1889–1896 shows this very clearly. In the spring of 1918 influenza was pandemic among the Allied and enemy troops. In May the disease had gained a strong footing in Spain, while in July the mortality rate was excessive all over Europe, in the United States and India. Both sexes are equally affected, and persons of any age and social condition may be attacked. From 1890–1917 about 70% of deaths from influenza occurred in persons over forty-five, but in 1918 only about 25%. In London in 1918 there were 894 deaths from influenza in the summer, 11,336 in the autumn, and 3267 in the winter, and just about half the total mortality occurred in persons aged fifteen to forty-five. In Scotland during the epidemic, July 1918 to April 1919, the number of deaths from influenza was equivalent to an annual death-rate of 4·3 per 1000. Pneumonia was present in 64% of the fatal cases. Case mortality was highest between the ages of twenty-five and thirty-five and lowest between five and fifteen. Case mortality is difficult to estimate, but in 1918 it amounted to 10% in some ships of the British Navy and 5% in the Royal Herbert Hospital, Woolwich.

Preventive measures are those to be adopted against all epidemic catarrhs. Respirators may be worn, especially by nurses of influenza patients. Gentle irrigation of the mouth and throat with saline or weak antiseptic solutions may be tried. Prophylactic vaccination is only under trial at the present time. Crowds should be avoided as much as possible. Places of entertainment—especially cinema houses—should be closed for short times periodically in order to flush the hall out with fresh air. Public notices may be distributed pointing out the main sources of infection and how best they may be avoided (*Proc. Royal Society of Medicine*, January 1919).

Cerebro-spinal Meningitis.—The causal agent is the diplococcus intracellularis meningitidis. Four strains have been isolated by Gordon, and serum has been prepared from each for use in diagnosis and treatment. The organisms are found in the naso-pharynx of human beings, and when the disease has manifested itself, they may usually be detected in the cerebro-spinal fluid. The condition is spread probably by missed cases and carriers. About 10% of persons who have never been in contact with a known case have been shown to carry the organism in

their throats, and practically the same percentage occurs among actual contacts. It is impossible by serological tests to decide whether all these organisms so isolated are capable of reproducing the disease, but it is well to consider such carriers as potential sources of infection. Pharyngitis is not a necessary concomitant of carrying the organism in the throat. Spread of the disease is aided by overcrowding and insufficient ventilation, possibly because such conditions lower the vitality of the mucous membranes. Cerebro-spinal meningitis is prevalent in the first half of the year with its maximum in April. This is just the time at which all catarrhal conditions are most common, and it may be put forward either that the climatic and other conditions that favour catarrh favour cerebro-spinal meningitis, or that the catarrh lowers the resistance of the naso-pharynx and so paves the way for an attack of meningitis.

The disease is more or less endemic in some of the large cities in this country, but it assumed epidemic proportions, mainly in the Army, in 1915. In 1913 there were 163 deaths from this cause, while in 1915 there were 1974, and in 1917, 1531. Epidemics have occurred at times all over the world, but the number of persons affected has never been large. Case mortality is usually between 30% and 40%. The suddenness with which persons are attacked, the rapidity of the course, and the high mortality all combine to fill the public with a dread of the name "spotted fever."

Preventive measures consist in isolating the patient, with all necessary disinfection, and in searching for carriers. All persons who have been in more or less intimate contact with the case should have their throats examined bacteriologically, and agglutination tests should be done on any suspicious organisms. Those individuals showing positive results must be isolated till at least two negative swabs are obtained from their throats at an interval of four or five days, no disinfectant having meantime been applied to the naso-pharynx. Open-air treatment and daily disinfection of the throat should be practised. A 1 in 1000 potassium permanganate solution may be used twice daily, or any other weak disinfectant. In the Army an inhalatorium was devised for use on a large scale. In it a 1% solution of sulphate of zinc was atomised by means of a jet of steam and the impregnated atmosphere inhaled by the contacts. The disease is notifiable now, and, during epidemics, attention should be specially directed to cases showing even indefinite nervous and other symptoms.

It is well to remember that in swabbing the throats of suspects, a curved swab, like West's, should be employed, as it is necessary to reach right behind the soft palate. Furthermore, as the meningococcus is a very delicate organism, these swabs should be removed with all speed to the laboratory for inoculation.

The best method is to have at hand a plate of the special medium recommended when an individual is being swabbed, and to inoculate the plate there and then.

Acute Anterior Polio-myelitis.—This disease has shown a marked tendency to spread since 1880. Epidemic manifestations were first noted in Norway and Sweden, and outbreaks have been reported all over Europe, Australia and North and South America. Since 1905 the incidence has fallen most heavily on the United States. In New York in 1905 some 2000 cases occurred, and in 1916 even more. It remains endemic in most large cities.

The disease is caused by a filter-passing organism. It has been reproduced in monkeys by intraperitoneal or intracerebral inoculation of an emulsion of the cord of a child dead of the condition on the fourth day. Infection may also be brought about in monkeys by rubbing the virus into the nasal mucosa (either injured or uninjured). In monkeys infected intracerebrally the virus is eliminated through the nasal mucous membrane, and in human beings the nasal mucosa has been proved to be infective. The virus is easily killed by heat, but withstands drying or cold for considerable periods.

The incubation period is uncertain, probably less than four days. Infection is concentrated in the spinal cord, the motor cells of the anterior cornua being specially involved. Seasonal prevalence is most marked in the warmer months, August and September in this country, and in certain outbreaks country districts have been affected more than large cities. Most cases occur in children under the age of five years, only about 10% of the incidence falling on adults. Males are affected slightly more than females, and show a somewhat higher mortality as well. The mortality rate varies very much in different epidemics, from about 5–30%. In England and Wales in 1917 there were 174 deaths from anterior polio-myelitis.

Experimental evidence would show that the disease is spread by personal contact, the virus being discharged, and gaining entrance, through the mucous membrane of the nose and throat. During epidemics many cases of "feverishness" are probably mild or abortive forms of the disease, and infection may be transmitted by them. Chronic carriers may play a part. As the virus resists drying it may probably be conveyed by dust or fomites, and attempts have been made to prove that the special incidence, frequently noted along the main roads of a county, might be due to dust infection. The theory of personal contact, however, cannot be eliminated in such a case. In the United States some observers maintain that the disease is inoculable through the bite of the stomoxys calcitrans or stable fly. Preventive measures consist in isolation and disinfection. Special attention should be paid to any clothing or linen soiled by

discharges. Weak disinfectants may be applied to the naso-pharynx, *e.g.* 1% hydrogen peroxide. Thorough watering of the streets should be practised during epidemic prevalence. The disease is notifiable in this country.

Encephalitis Lethargica is a disease only recently defined, which assumed a slight degree of prevalence all over England in the spring and summer of 1918. It was made notifiable by order of the Local Government Board. Some observers have held that the condition is but a manifestation of the Heine-Medin group of diseases, of which acute polio-myelitis is the commonest. Encephalitis lethargica, however, presents a characteristic syndrome, and, histologically, differences between the two diseases appear to exist. The incubation period is uncertain, and is followed by a prodromal period lasting usually from one to seven days. Symptoms of lethargy and drowsiness appear, often passing on to coma. There is usually a moderate degree of fever, but in certain cases no rise of temperature may occur. Slow speech and delayed response to questions are characteristic. Irritative and paralytic affections of the eyelids and eyeballs are common, especially bilateral palsy of the third pair of cranial nerves. Headache, fits, spastic phenomena and paralysis (usually bilateral and frequently facial) have all been noted. Stupor may persist for two to five weeks, and recovery from the disease is slow and tedious on account of great prostration. Some 20% of the cases investigated ended fatally. All ages were affected, and males slightly more than females. The incidence was greater in urban than in rural districts. In this country most of the cases occurred between March and May. Similar outbreaks have been reported from Austria in 1917 and France in 1918. At its commencement the disease was confused with botulism, solanin poisoning, etc., but the only condition likely to be mistaken for encephalitis lethargica is acute polio-myelitis. Many of the cases, however, occurred in places where polio-myelitis was either absent or very rare. Apparently its prevalence in epidemic form depends on conditions other than those necessary for the presence and epidemic prevalence of true polio-myelitis.

The histological changes consist of a bilateral cellular infiltration round the small veins and venules and in the parenchyma of the grey matter, sometimes accompanied by microscopic hæmorrhages round a few of the venules. The lesions are most extensive in the basal nuclei of the brain and in the upper part of the pons, especially in the grey matter of the floor of the fourth ventricle. The spinal cord is but slightly affected. Plasma cells are numerous and polynuclear leucocytes are rare. Degenerative changes in the nerve cells are relatively slight. No positive bacteriological findings were obtained (L.G.B. Report, New Series, No. 121, 1918).

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Rheumatic Fever has shown almost epidemic prevalence at more or less irregular intervals of from three to six years. There appears to be definite relationship between this disease and deficient rainfall, and it has been noted that rheumatic fever, erysipelas, and puerperal fever show very similar curves with regard to seasonal prevalence and mortality. Although the causal agent has not so far been determined, a diplococcus has been isolated from rheumatic lesions, which has to some extent reproduced the disease on inoculation into rabbits.

Puerperal Sepsis.—According to the rules of the Central Midwives Board, medical opinion on a lying-in case must be obtained, when the temperature rises above 100·4° F., with corresponding increase in the pulse-rate, for more than twenty-four hours.

In 1917 the number of deaths assigned to pregnancy or childbirth corresponded to a rate of 3·89 per 1000 births. "Puerperal fever" accounted for 1·32 deaths per 1000 births. For the years 1904–1907 the death-rate from "puerperal fever" was 1·8 per 1000 births. It will be seen that, though the tendency is to decrease, the rate is still high. The diminution has been most marked in lying-in hospitals. Outside these institutions there has been little decline. The rate is specially heavy among those upon whom some operative procedure has been undertaken during confinement, and crowded industrial centres, like Lancashire and Wales, suffer more than rural districts. The case mortality varies, but amounts at times to 35% or 40%. The maximum mortality occurs in January, and a certain relationship has been described between the seasonal mortality curves of this condition and erysipelas.

Whenever a case of puerperal sepsis occurs in the practice of a midwife, thorough cleansing and disinfection of her own person and professional belongings should at once be undertaken.

Erysipelas has an incubation period usually of three to four days, and may occur at all ages. It is specially fatal in infants, and the mortality is greater in winter than in summer. The death-rate in England and Wales in 1917 was 0·017 per 1000, and of recent years there has been a gradual decline in the rate. The causal organism is the streptococcus erysipelatis.

Enteric Fever has an incubation period of ten to fourteen days (up to twenty-three days); rose spots appear between the seventh and the twelfth days, and isolation must be maintained till negative bacteriological findings have been returned after examination of the fæces and urine on three separate days.

The disease is caused by the B. typhosus. The organism is destroyed by heating in water, etc., to 60° C. for twenty minutes, but it resists cold and ordinary drying. It may live for seven to ten days in ordinary water or aerated waters, nearly three weeks in oysters, but less if they are transferred to clean water, about three weeks in soil, five days in sewage and seventeen days in

khaki drill or serge fouled with enteric fæces. It has been recovered after considerable periods from butter, cheese and ice-cream. The natural habitat of the organism is the human body, and although it may remain alive outside the body it rarely multiplies elsewhere, with the possible exception of milk.

The disease is found all over the world, and is endemic in certain areas. Seasonal prevalence is most marked in the last four months of the year. The age group most commonly affected is fifteen to twenty-five years. Between five and twenty years males suffer more frequently, but females show a higher death-rate. The average mortality rate is about 15% (M.A.B. 1918, 13·4%). The death-rate in England and Wales has been steadily declining, till in 1917 it was only 0·028 per 1000, as compared with 0·39 in 1869. The enteric death-rate is to a certain extent an index of the completeness of the sanitary measures practised in any country. Thus, in the United States, where water supplies are perhaps more liable to contamination than in this country, the death-rate in many cases has remained steadily high. In various parts of England, where the water carriage system has not been installed and possibilities of infection are multiplied through the agency of dust and flies, the rate shows a considerable excess over areas where more modern methods have been installed. Enteric fever is spread chiefly through the medium of water, food (especially milk, shell-fish, vegetables and fruit), fomites and dust. Infection through dust and flies was proved in the South African War. Direct infection from an actual case occurs at times, particularly among nurses. Modern knowledge goes to prove that many of the outbreaks of enteric fever that occur are traceable to carriers. From 2–4% of all enteric fever patients discharge the bacilli in their urine and fæces during or after convalescence. Other individuals may excrete the organism, though they have never apparently shown any symptoms of the disease. It has been estimated that 1 per 1000 of the population is a carrier and that 25% of all chronic carriers have never been diagnosed as suffering from the disease. Carriers may be divided into (*a*) temporary, or those in which the condition does not last more than three months, and (*b*) chronic, or those in which the condition persists for years. Women are commoner chronic carriers than males—in the proportion of five to one. This is especially important in view of the possible contamination of food during its preparation for the table. The majority of chronic carriers are of middle age and gall-stone trouble has been noted in 13·6% of them. On the other hand, temporary carriers are usually young persons, and, though females are more numerous than males, the proportion is only 1·4–1. The bacilli may be excreted in both urine and fæces in the same individual, but the urinary carrier, though less common than the purely fæcal, is the more dangerous from his greater liability to

contaminate his hands during micturition. In either case the bacilli tend to be discharged intermittently, so that, though the carrier may appear free during a period of weeks or even months, he may give positive results during later bacteriological examinations. While the Widal reaction is said to be positive in the majority of carriers, it is essential to demonstrate the typhoid bacilli either in the fæces or urine before certifying any person as a carrier. Under the Public Health (Pneumonia, Malaria, Dysentery, etc.) Regulations, 1919, enteric and dysentery carriers may be excluded from all trades concerned with the handling of food and drink.

The value of prophylactic vaccination against enteric has been amply demonstrated during the European War. Not only is the vaccinated individual far less liable to contract enteric than the unvaccinated, but in the event of his being infected he is much less likely to succumb. The official vaccine contained 1000 million B. typhosus and 750 million each of B. paratyphosus A. and B. The dose was 0·5 c.c., followed after ten days by 1 c.c.

Great care must be exercised in disinfecting all bed linen and articles handled by a patient. The fæces and urine must be treated with special care. It is advisable to soak all linen in a cold solution of 1 : 1000 perchloride of mercury, and subsequently to disinfect with steam under pressure. Fæces and urine may be received into dishes containing some 5% carbolic, and more disinfectant should be added after use. Fæces should be broken up with a piece of stick so that no lumps remain. At least two hours contact with the disinfectant should be given before excreta are discharged down the drain. When a water carriage system is not available, excreta should be either buried or burned after disinfection.

Paratyphoid Fever may be caused by B. paratyphosus A. or B. The latter is the commoner in Europe and America, and during the War the former was the more frequently found in Egypt and Mesopotamia. The condition is closely allied with typhoid fever, and is spread in the same ways. The incubation period is about ten days, and the disease is generally mild with a very low case mortality. The bacilli are found in the blood early in the disease and in the fæces later on. It is not so commonly isolated from the urine as is B. typhosus in enteric fever. The prophylactic vaccine adopted during the War gave good results.

Dysentery.—Amœbic dysentery is due to the protozoon entamœba histolytica, and is a disease of tropical and subtropical countries. It is the cyst form of the protozoon that conveys infection, for it is very resistant outside the body. It is found in the formed stools of convalescent cases, and may contaminate water supplies, food and dust. Flies may swallow the cysts and pass them unaltered in their fæces. It has been

found that quite a number of persons who have lived all their lives in this country may be infected with entamœba histolytica without showing any symptoms. Further, a definite percentage of dysentery cases invalided from France during the War appear to have contracted the disease either there or in England. The main features of the condition are the frequency of liver abscess as a sequela, particularly in badly treated cases, and the amenability of the condition to emetine in the form of emetine-bismuth-iodide in doses of 3 grains daily for twelve or more days consecutively.

Bacillary dysentery is usually the result of either Shiga's or Flexner's B. dysenteriæ. Various other organisms might be included as causal agents. During the War Shiga's bacillus was the one more commonly found. It is this strain, too, that has been isolated most frequently from cases of asylum dysentery. Bacillary dysentery is constantly present in the tropics, but is also common in temperate countries. It was a cause of quite considerable invaliding in France during the War. The incubation period varies from one to seven days, and the disease is characterised by much tenesmus and fluid stools, consisting mainly of blood and mucus in the later stages. Inasmuch as the disease is helped in its spread by overcrowding and dirt, it has always been looked upon as an almost inevitable accompaniment of military campaigns. The mortality varies very much, from 6–30%. Infection is conveyed in the same way as typhoid fever, and the preventive measures are identical. Power to control carriers is granted under the 1919 Regulations. Prophylactic vaccines have given more or less encouraging results.

Other forms of dysentery are due to Lamblia intestinalis and Balantidium Coli, but both conditions are rare in this country.

Epidemic Enteritis is of special consequence, inasmuch as infantile diarrhœa is the cause of death in many children under one year of age. In 1914 in England and Wales there were 17·37 deaths from this cause per thousand births. A marked decline, however, occurs after the first year of life. The disease is much more prevalent in big towns than in the country. In the county boroughs of the north in 1914 the infantile mortality rate from diarrhœal diseases was 23·54, while in rural districts of the south it was only 6·11. Various organisms have been isolated from the stools and considered to be causal agents—B. enteriditis of Gærtner, B. enteritidis sporogenes, Shiga's B. dysenteriæ, Morgan's bacillus, B. proteus vulgaris, etc. It is probable that the condition may be due to any one of a whole variety of organisms.

There appears to be a definite connection between the prevalence of diarrhœa and the temperature. Thus in 1911 (a hot summer) the infantile death-rate in England and Wales from this disease was 36·20, while in 1912 it was only 7·72. Ballard showed that the wave of mortality began to rise in the big cities

only when the 4 foot earth thermometer reached a mean of 56° F. This temperature curve and the mortality curve from epidemic enteritis thereafter closely followed one another. The highest mortality occurs in the third quarter of the year, but the fall is prolonged far into the fourth. The disease is more prevalent among bottle-fed than among breast-fed children. It is also more widespread in towns where scavenging arrangements are poor, where no water carriage system is in use, where yards are badly paved and where much contaminated dust is present ready to infect any milk, etc., on which it may be blown. Flies are certainly a common medium of infection.

Preventive measures consist in thorough cleansing and watering of all streets during hot and dry seasons, protection of all food from flies and dust, and pasteurising or boiling of milk.

Cholera is due to the vibrio of cholera. It is not a very resistant organism, but it appears to remain alive for considerable periods (even months) in ordinary water. In stools in the dark it may be recovered after two to three weeks. It is readily killed by drying, sunlight, heat and disinfectants.

The disease is endemic in lower Bengal, and has spread from there all over the globe. Pandemics occurred in 1823, 1826–1832, 1846–1860, 1863–1874 and 1884–1892. From 1904–1911 it was somewhat widespread in Russia, southern Italy, Portugal, and Turkey. England was affected in 1831, 1848–1849, 1854 and 1865–1866. Cholera has reached Europe along the main lines of travel from India: (1) through Afghanistan and the caravan routes to Russia; (2) by the Gulf of Persia to Syria and Egypt and across the Caspian to Russia; (3) by the pilgrim traffic to the Red Sea, thence to Egypt and the Mediterranean; (4) by the trans-Caspian railway and the Caspian steamers to Russia in 1892. Thus in some ways the quicker the means of transport the more rapidly is cholera liable to spread. This country has usually been infected from Russia and Germany *via* our North Sea ports.

The incubation period varies from a few hours to five days, and the patient remains infectious as a rule till the stools become fully formed again. He must be isolated, of course, till no vibrios can be discovered in the excreta. The case mortality is high, usually 30–50%, children and old persons being specially liable to succumb. In Europe the greatest prevalence was reached from June to August, and the disease usually died down with the approach of cold weather.

Cholera is spread mainly by carriers, through the agency of food, water and fomites, aided by defective sanitary arrangements and flies. Convalescents may discharge the vibrios in their fæces for three weeks or more after the attack, but chronic carriers are found in whom a gall-bladder infection has possibly supervened. Should diarrhœa, for some cause or other, occur in such a person, virulent vibrios may again be excreted. Flies

may discharge vibrios in their fæces for a day and a half after feeding on cholera stools. During outbreaks of the disease no uncooked food should be eaten, raw fruit and vegetables being especially dangerous. All milk and water should be boiled. Strict isolation of patients must be practised and careful disinfection of all excreta, fomites, etc., carried out. Prophylactic vaccines have proved useful, two doses of 15,000 million bacilli being given at ten days interval. A modified immunity is conferred for about four months. Quarantine no longer exists in this country, but has been replaced by the Cholera Regulations (see p. 305). These powers, coupled with good port sanitation and control over the entrance of aliens and the importation of rags from infected ports, constitute our chief preventive measures.

Venereal Disease includes syphilis, gonorrhœa and soft chancre. The Royal Commission on Venereal Diseases stated that about 10% of the population in our large cities was infected with syphilis. The incidence of gonorrhœa was supposed to be even greater. As is well known, these diseases are responsible not only for a large percentage of mental and physical defects among the actual sufferers, but also for a large proportion of children either born dead or dying in early infancy. From an examination of a thousand babies from working-class families, Fildes found only 0·59% with evidence of syphilis; of the mothers, twenty-seven (3·9%) gave a positive Wassermann reaction, but only four altogether transmitted syphilis. Mott found that, out of 175 pregnancies in thirty-four syphilitic mothers, only thirty healthy children resulted. Of the remaining 145, still-births or deaths in infancy accounted for 104, while forty-one were living but maimed. Osler has estimated that between 6000 and 7000 persons die of syphilis yearly in England and Wales, but, as death certificates are apt to state inaccurately the cause of death in such cases, the Registrar-General's returns cannot altogether be relied upon. In 1917 the death-rate from syphilis was 0·061 per thousand living, and that for gonorrhœa 0·001. A record of over 4000 Austrian Army officers who contracted syphilis between 1880 and 1900 showed 14·64% actually dead or directly disabled as a result of the disease (Rosenau). Returns for the British Army indicate a marked decline in the incidence of venereal disease—from 275 per thousand per annum in 1885 to 50·9 in 1913. From 1916–1918 the incidence among all troops in the United Kingdom was about 75 per thousand.

The control of venereal disease has always been a matter of great difficulty. Between 1870 and 1882 attempts were made to apply the Contagious Diseases Acts in garrison towns in this country. Prostitutes could be examined and, if diseased, ordered to be treated in hospital. Furthermore, periodical inspection of such persons was instituted. These measures proved of little avail, and the reduction in the incidence of venereal

Disease.	Causal agent.	Incubation period. (days).	Appearance of rash. (days).	Duration of isolation.	Quarantine. (days).
Small-pox (Variola).	—	12 (10–14)	3–4	Till scabs gone (6 weeks)	15
Scarlet fever.	Complications usually streptococcal.	1–6	1	6–8 weeks. No discharges.	7
Cholera.	Vibrio choleræ	1–5	—	4–6 weeks. Three neg. exams. of fæces.	7
Diphtheria.	Klebs-Lœffler Bacillus.	2–8	—	4 weeks if no discharges or complications. Three negative throat swabs.	Till throat swabs negative.
Erysipelas.	Streptococcus Pyogenes.	1–5	Inflammation first day.	Till skin clear.	7
Enteric fever.	B. Typhosus.	5–21	7–10	Till three negative examinations of urine and fæces.	—
Typhus fever.	—	5–14	5	5 weeks.	21—all contacts to be cleansed.
Plague.	B. Pestis.	2–7	—	4 weeks.	10—all contacts to be cleansed.
Tuberculosis.	B. Tuberculosis.	—	—	—	—
,, (pulmonary).	,,	—	—	—	—
Cerebro-spinal meningitis.	Diplococcus intracellularis meningitis.	1–28	—	Till recovery, and throat swabs negative.	Till throat swabs negative.
Acute polio-myelitis.	—	? 1–4	—	—	—
Measles.	—	10–14	4	4 weeks.	21
Rubella	—	11–18	1	3 weeks.	21
Chicken-pox (Varicella).	—	10–16	1	Till skin clear.	21
Whooping-cough.	B. Pertussis.	5–14	—	Till two weeks after last whoop.	15
Mumps.	—	14–22	—	3 weeks	—
Influenza.	?Pfeiffer's B.	1–4 (2)	—	Till convalescent	—
Pneumonia.	Pneumococcus, etc.	—	—	—	—

PRINCIPAL INFECTIOUS DISEASES.

Seasonal prevalence.	Age incidence. (years).	Case mortality. (percentage).	Death-rate per 1000 living. 1901–1910.	1917.	Remarks.
Jan.–June.	Depends on vaccination.	3% vaccinated, 30 % unvaccinated.	0·013	0·000	Notifiable.
Sept.–Dec.	1–5	1·8% (M.A.B., 1918).	0·109	0·022	"
June–Aug. (Europe.)	All ages.	30–80%.	—	—	"
Sept.–Dec.	2–10 (3–4)	7·7% (M.A.B., 1918). Less if antitoxin given very early.	0·183	0·132	"
Spring.	—	4–7%	—	0·017	"
Sept.–Oct.	15–25	7–20%, 13·4% (M.A.B., 1918).	0·091	0·028	"
Winter and spring.	All ages (15–25).	5–20%, 50% in persons over 50 years of age.	—	—	"
Early autumn in Europe.	—	50–90%	—	—	"
— —	— —	— —	1·646 1·143	1·624 1·135	" "
Jan.–June.	Under 20	30–40%	—	0·027	"
July–Sept.	Under 20	28–35%	—	—	174 deaths in 1917. Notifiable.
Nov.–Jan. and May–June.	Under 5 (1–2)	13·2%, (M.A.B., 1918).	0·318	0·308	Notifiable, 1915–1919.
—	—	—	—	0·003	" "
—	—	—	—	0·002	Not notifiable.
March–April	Under 5 (1–2).	17·5% (M.A.B., 1918).	0·286	0·134	" "
Spring and autumn.	Children and young adults.	—	—	0·001	" "
Usually winter and spring.	—	0·05–10%	0·208	0·213	See 1919 *Regulations.*
Winter.	1–6 and over 15	15–25%	1·254	1·144	See 1919 *Regulations.*

disease in the forces has taken place since the repeal of these Acts. Recognised prostitutes account only to a small extent for the spread of disease, hence other measures of control must be sought.

The prevalent opinion in this country is that the best results are likely to be obtained from encouraging young adults to lead clean, healthy lives, and from providing centres for the expert diagnosis and early treatment of venereal disease should it be contracted. In 1916 the Public Health (Venereal Disease) Regulations were issued, mainly on account of the probable spread of these diseases as a result of the War. The regulations require the councils of counties and county boroughs to make arrangements for providing any practitioner with scientific reports on material from patients suspected to be suffering from venereal disease. These councils, in addition, must submit to the Local Government Board schemes for the treatment in institutions of cases of venereal disease and for supplying medical practitioners with salvarsan and its substitutes. The schemes, when approved, must be carried out by the councils (75% grant). All information concerning persons treated must be regarded as confidential. Power is given to provide instructional lectures and printed information on questions relating to venereal disease. These regulations will in the long run ensure that every case of venereal disease may have the complaint diagnosed and treated by experts within the shortest possible time. Evening clinics in hospitals are being held, and every endeavour is made to secure as much privacy as possible for those attending. These measures would prove of little avail if unqualified persons were at liberty to practise the treatment of venereal disease, hence in 1917 the Venereal Disease Act was passed. This Act prohibits, under penalty, any but qualified medical practitioners from treating such diseases in any area to which this section of the Act may be applied—*i. e.* any area which has in operation an approved treatment scheme. In addition all advertisements offering treatment for such diseases are forbidden, and no label may be affixed to any preparation stating that it will prevent or cure venereal disease.

Personal prophylaxis is advocated by many. In various branches of our armies it was shown that men who cleansed themselves carefully with 1 in 1000 permanganate and then anointed the affected parts well with 30% calomel ointment—as soon after connection as possible—experienced a much lower incidence of venereal disease. In some units facilities were provided in special early treatment sheds attached to latrines, etc., but in others "prophylactic packets" were issued to the men for their own use. The latter method gave the better results. Discussion has waged round the advisability of making such prophylactic treatment available for the general public. The

arguments brought forward against this are: (1) That such practices are in no way certain preventives, and a false sense of security would be given were official approval forthcoming for them. (2) That it would be an incentive to immorality through removal of the fear of contracting venereal disease. (3) That illicit intercourse is frequently indulged in either without premeditation or under the influence of liquor, when preventive measures would not be available or, if available, would not be properly carried out. (4) That medicaments so issued would be used not only as prophylactics, but also as a means of improper treatment, should venereal disease actually supervene. (5) That a huge element of public opinion would be outraged, in that incontinence would receive an almost official sanction, and a death-blow would be dealt to a national crusade for a higher moral standard of living. Many medical men, however, point out that we are concerned not only with the effects produced on the culprits themselves, but also with the suffering inflicted on the innocent and on those yet unborn. Incontinence in any form is not going to be stamped out of the human race within a short period of time, and meanwhile, if any benefit can be derived from prophylactic measures (and Army experience seems to show it can), such measures should be made available for the public. (Venereal Diseases Circulars, Regulations and Memorandum, 1916. Prophylaxis against Venereal Disease—note by the Chairman of the Inter-departmental Committee [Cmd. 322], 1919.)

Anthrax affects mainly the ungulates, although probably no class among the mammalia is completely immune. In animals, anthrax is practically always gastro-intestinal in type, the result of infected pastures or infected grain and cake food. The period of obvious illness is short. In man infection is conveyed by animal products, such as skins and hides, wool, hair and bristles. Shaving brushes have been proved to be the medium in several instances. As the bacilli produce their spores only in the presence of free oxygen, whenever the blood or discharges from an infected animal come in contact with the air, the conditions necessary for spore formation are supplied. The spores may remain alive for years.

Among workers in wool and hair three manifestations of the disease may occur: (*a*) Malignant pustule or cutaneous anthrax. (*b*) Gastro-intestinal anthrax (ingested infection). (*c*) Pulmonary anthrax (inhaled infection). Workers in hides usually suffer from cutaneous anthrax. The incubation period varies from one to ten days. Early diagnosis and effective treatment have considerably lowered the mortality. Statistical evidence is available proving that, when the cases were treated by a practitioner having special knowledge of anthrax, diagnosis was made twenty-four hours earlier than in those seen by other practitioners. In addition, in the former instance 74% developed

mildly and only 7·4% were fatal, in the latter instance 50% developed mildly and 15% proved fatal. Sclavo's serum has been of benefit in treatment. In internal anthrax death usually supervenes on the third to the fifth day of the disease, sometimes earlier. The death-rate for England and Wales in 1917 was 0·001 per thousand living.

Infected wool and hair appear to come principally from India, Central Asia, Persia and Mesopotamia, Asia Minor, Egypt and Russia. All materials from Central, Southern and Western Asia and from Egypt should be classed as dangerous. Blood-stained material is always more to be dreaded. All cases occurring in factories and workshops must be notified to the Chief Inspector of Factories.

By the Anthrax Order, 1910, the M.O.H. must be notified if a case of anthrax in an animal arises in his district. He is usually supposed to advise on the question of disinfection. At all events, the Order requires the carcase to be destroyed by burning, either on the farm or in other suitable premises (usually the nearest destructor). If the carcase is removed, all natural openings must be plugged with tow soaked in strong disinfectant. If cremation is impracticable, the carcase must be buried at least 6 feet below the surface of the ground and surrounded on all sides with a layer of not less than 1 foot of quicklime. The site of burial must be removed from any dwelling-house or water-supply, and in a place to which cattle will not have access. In no case must the skin be cut prior to destruction of the carcase, save by a qualified Veterinary Surgeon for the purpose of diagnosis (sample of blood usually taken from an ear). Thorough disinfection of the cattle-shed, and utensils, vans, etc., in any way contaminated, must be carried out, *e.g.* drenching with 5% carbolic acid, careful scraping and scrubbing followed by scouring with 1% (minimum) solution of chloride of lime containing at least 30% available chlorine or with 5% carbolic acid. By these means indigenous anthrax has been practically stamped out in this country. In other places, however, such precautions are not taken and, on account of the large amount of infected material imported and the apparent inefficiency of existing regulations, a departmental committee was appointed in 1913 to consider the whole question. In 1918 it made the following recommendations regarding wool, goat-hair and camel-hair—

1. The policy of attempting to control the danger of infection from anthrax in wool by regulations under the Factory Act should be abandoned, and instead, the principle of compulsory disinfection substituted.

2. The following method of disinfection is recommended—

Stage I. Preliminary treatment, consisting of agitation for twenty minutes in a solution of soap in water, preferably contain-

ing a little alkali like sodium or potassium carbonate, assisted by squeezing through rollers.

Stage II. Disinfecting treatment, in which the material is agitated for twenty minutes in a 2–2½% solution of formaldehyde in water at a temperature of 102–105° F., assisted by squeezing through rollers.

Stage III. Drying in a current of air heated to 160° F.

Stage IV. Standing for a short time to ensure, by the progressive action of the formaldehyde, the complete destruction of any weakened spores which may in rare cases survive Stages II and III.

3. Disinfection of wool and hair should be permitted only in central disinfecting stations, the sole business of which is disinfection. Thus East Indian wool and goat-hair should be dealt with at Karachi and Bombay, Persian wool at Basra, and Egyptian wool at Cairo. (These materials account for about 70% of all cases of anthrax in this country.)

4. All materials included in the dangerous list should be allowed to land only at fixed ports, unless accompanied by a certificate of disinfection; and the port or Customs officers should be empowered either to refuse admission of any such material or to permit it to be landed only if transferred direct from the ship to a disinfecting station. (*Report of the Departmental Committee on Anthrax*, vol. ii. [Cd. 9771], 1918.)

It has been suggested that hides should be soaked for twenty-four hours in a 1–2% solution of formic acid and 0·02% perchloride of mercury, and subsequently treated with common salt. Horse-hair may be boiled or disinfected by steam under pressure.

At present preventive work is carried on in factories, and includes exclusion of workers suffering from skin lesions, wearing of overalls, sufficiency of washing accommodation, damping bales of hair, etc., to keep down dust, and exhaust ventilation.

Glanders and Farcy rarely affect man. The condition may be either acute or chronic, and in either case the mortality is high. It is met with in horses, mules and asses, and a horse may carry the bacillus mallei without showing any symptoms. Diagnosis is made in doubtful cases by injection of mallein. The inspectors of the Local Authority must notify the M.O.H. on becoming aware of a case in the district. The disease may be controlled among horses by quarantine of all imported animals till they are proved free from the condition, slaughter of the infected, avoidance of common drinking-troughs and complete disinfection of infected stables.

Antinomycosis is not a common disease in man, though fairly widespread in cattle and less so in horses and swine. It is inoculable, and usually runs a chronic course. Frequently the condition is diagnosed as tuberculosis of bone, lungs, peritoneum,

etc. It is possibly inoculated by means of particles of grain infected with the fungus—streptothrix bovis.

Rabies is a disease to which all warm-blooded animals are susceptible. In the huge majority of cases it affects dogs, but cats, horses, cattle, foxes, deer, pigs and sheep may also suffer. The condition in man is known as hydrophobia. In dogs usually the "furious" form manifests itself. Towards the end paralysis sets in. In rabbits the "dumb" or paralytic type of disease is always present. The virus, which is supposed to be a filter-passer, is found constantly in the saliva, salivary gland, brain and spinal cord. It is occasionally present in the peripheral nerves, lachrymal gland, pancreas and milk. It is never found in the blood, lymph or urine. Diagnosis is made chiefly by the finding of Negri bodies in the cells of the cornu ammonis of the hippocampus major or in the Purkinje cells of the cerebellum. They are considered to be most probably cellular changes brought about by the virus, and are found in at least 95% of rabid dogs examined. They are also found in the human brain in cases of hydrophobia. Subdural inoculation into a rabbit of an emulsion of the cord of a dog dead of rabies is the most certain method of diagnosis. The disease is communicated always through a bite or through deposition of saliva, *e. g.* by licking, on an abraded skin. The virus is also capable of passing through an uninjured mucous membrane. The saliva of the dog may be infective as long as five days. Bites on the head, face or neck are the most dangerous, as the virus has only a short distance to travel along the nerves before reaching the brain. Cauterisation, thoroughly performed within half an hour of the bite, will prevent hydrophobia in many cases, but is no good after twenty-four hours. Pure carbolic acid, izal, lysol and iodine may be swabbed into the wound and subsequently washed out. When a person is bitten by a suspected dog, the dog should be kept under observation for a period of ten days. If the dog develops rabies after that, the individual bitten has nothing to fear, as the saliva of the dog is never virulent ten days before the disease manifests itself. If the dog develops rabies within the ten days, antirabic treatment of the bitten person should be undertaken at once. If, however, the bite has been inflicted on the head, face or neck, treatment should be given immediately in an infected district, if the dog was a stray one. Should a dog be destroyed after biting a human being, the brain should be sent to a central laboratory for diagnostic purposes.

In man the disease appears most frequently in the second or third month after infection, rarely after the sixth month. The nearer the bitten area is to the brain, and the more severe the bite, the shorter is the incubation period. It has been estimated that from 16–60% of the cases bitten developed hydrophobia prior to the use of Pasteur's treatment. Among nearly 40,000

persons receiving antirabic treatment at the Pasteur Institute of Paris, there was only 0·39% of failures. At the Pasteur Institute of India, Kasauli, between 1912 and 1916, a total of 22,519 persons were treated by carbolised vaccine, with 0·68% of failures.

The principal measures of prevention of rabies in dogs are: (1) Application of the Muzzling Order for a sufficiently long period; (2) restriction of movement of dogs; and (3) quarantine for a fixed period of all imported dogs (*B.M.J.*, September 13 and 20, 1919, Sir David Semple).

Malta Fever (Undulant Fever) occurs mainly in the Eastern Mediterranean area. The micrococcus melitensis is the causal agent, and may be found in the blood and urine of sufferers. The chief cause of infection is the goat, for the organism may be excreted freely in the milk of such animals without any symptoms of disease being present. Cream and cheese (goats' milk) may also contain the micrococci. The organism is fairly resistant, so that when infective urine is passed on the ground, infection may be spread through the contamination of food by dust and flies. Human carriers may also assist the spread of the disease. Cows, sheep, horses, mules and dogs contract the infection, though less commonly than goats. The condition is characterised by an incubation period of five to fifteen days, followed by irregular bouts of fever, accompanied by joint pains and neuralgia. These febrile periods last about ten days, and are separated from one another by intervals of comparative freedom from symptoms. The disease may run a course of from three months to a year. As a rule 2–3% of the cases end fatally. Diagnosis is made by isolation of the micrococcus from the blood. Prior to 1906 British troops in Malta suffered considerably from this disease, but the prohibition of fresh goats' and cows' milk in that year reduced the incidence to practically nil.

Plague.—Since the great plague of 1665 this country has been more or less free from visitations, in spite of the fact that plague has been pandemic during the past twenty-five years. In 1894 it appears to have originated in the interior of China, in 1895 Hong Kong was affected, in 1896 extension to India occurred, and thence it spread to every corner of the globe. Some authorities trace the origin of the disease to infected "tarbagan-marmots" on the borders of Mongolia and Manchuria, and assert that cases occurred prior to 1894 in native hunters and trappers of those animals. By these means rats were infected in more populous localities, and the virus was spread generally through the agency of rat fleas. Cases occurred in Glasgow in 1900, and a few have been detected in various ports in this country from time to time. In 1910 a small outbreak was recorded in Suffolk, where the local rats were found to be infected. The disease is due to the B. pestis, and is really an epizootic in

rats and other rodents, among whom a heavy mortality usually precedes an epidemic in man. The bacillus is but little resistant outside the body of its various hosts. Bubonic plague is conveyed from rat to man by the rat flea, Xenopsylla cheopis; when rats fall ill or die, the fleas leave their hosts. Such fleas may remain infective for upwards of six weeks. Both the brown and the black rat may be infected, but as the latter is more closely associated with man it is the greater source of danger. Rats are brought to this country from infected ports, especially in grain and cotton ships. After a flea has sucked infected blood, the plague bacilli multiply in the proventriculus and gradually block the œsophagus. Through the efforts of the flea to suck blood, some of this mass is regurgitated on the skin of the next individual attacked by the flea. The fæces of the flea, which are also full of the bacilli, may be deposited on the skin. In either case the infection may be rubbed into the puncture wound or scratch marks, and bubonic plague results.

The incubation period varies from two to eight days, hence a quarantine limit of ten days is usually imposed. Patients should be isolated for a month. Age and sex have little influence. Seasonal prevalence is most marked during the cool season in hot climates. A temperature of over 80° F., combined with absence of moisture, usually brings an epidemic to a close. In this country, conversely, plague is more liable to occur in late summer and early autumn. In India, case mortality has generally amounted to about 75%, and from 1896–1914 eight and a quarter million persons died of plague. Europeans suffer much less and show a lower mortality than do natives.

Three forms of plague are distinguished—

1. Bubonic plague, the least fatal; infection conveyed by fleas and not directly infectious from man to man.
2. Pneumonic plague, where infection is conveyed through the droplets of sputum given off on coughing, etc.
3. Septicæmic plague, rapidly fatal.

Preventive measures include the use of pullicides and suitable protective clothing by persons attending cases of plague. Masks are advisable where pneumonic plague is being dealt with. Haffkine's vaccine and Yersin's serum are both advocated. The only general measure of prophylaxis is to carry out a thorough campaign against rats.

Rats (Hinton and Hanna, *J. Roy. San. Inst.*, September 1919).

Two species of rat are of special consequence—Rattus rattus, or the Black rat, and R. Norvegicus or Brown rat. In Britain generally the black rat is rare, but it is still common in ships and ports. In the city of Liverpool the proportion of black rats to brown is about one to nine, but in the dock area the proportion is ten to one. There is no recognised difference in colour in spite of the names. The two species may be distinguished in

the following way: The black rat is much lighter in build, its tail is never shorter than the head and body combined, its ears are large and translucent, and its hind foot from the heel to the tip of the toe (exclusive of the nail) is not longer than 40 mm. The brown rat is larger, more clumsy, blunt-nosed, has small, thick ears, and a hind foot at least 45 mm. long. The black rat feeds mostly on grain, while the brown rat eats filth of any sort. Rats begin to breed when only two months old, and five or six litters may be born in a year. The average number per litter averages eight in the country and ten in the towns. The normal gestation period is about twenty-one days.

An organised campaign against rats is necessary, not only on account of the damage they inflict upon foodstuffs, etc., but by reason of their significance as carriers of disease.

Rat Suppression.—As rats move about either in search of food or at changes of season, and are specially liable to leave an area where they are in any way disturbed, the best-laid plans are apt at times to go astray.

Destructive methods.—1. *Bacterial virus and poisons.* Propagation of the virus from rat to rat is feeble, and human infection occasionally occurs. Chemicals are better, such as strychnine, arsenic, phosphorus, barium carbonate, extract of squills. Rats, however, are liable to die in inaccessible places and cause a nuisance. In India poison baits are recommended to be made as follows: 1 lb. of barium carbonate is mixed thoroughly with 3 lbs. of flour made from the grain which forms the staple food of the local population. Sufficient water is added to make a fine paste. Some 2300 baits, each containing 3 grains of barium carbonate, may be made from the mass. Clean hands and dishes are necessary (*B.M.J.*, November 15, 1919, Major Norman White, I.M.S.).

2. *Trapping* has this advantage, that all rats caught can be counted and examined if necessary. Large wire traps are best, and these should be well baited, covered with a bag and left open for a few nights to let the rats get accustomed to them. Birdlime tray traps (linseed oil and resin or varnish), with a bait placed on a piece of cardboard in the centre, answer well. Rats on ships are said to be getting very shy of traps.

3. *Fumigation.* Carbon bisulphide, sulphur dioxide, mixtures of CO and CO_2, and hydrocyanic acid gas have all been tried. SO_2 delivered by means of a Clayton machine is perhaps the most favoured method for the fumigation of ships. At least 3 lbs. of sulphur must be burned per 1000 cubic feet of hold, and the process must be continued for about twelve hours. A uniform diffusion of 0·5% would kill all rats and fleas in two hours, but on account of the rapid absorption of the gas by most articles of cargo, this percentage is never attained throughout a loaded vessel. Moist articles of food, such as fruit, flour and

meat, are also apt to be made completely uneatable. Dry stuffs retain enough of the SO_2 as a sulphite to affect their taste. Liquid sulphurous acid is as effective, but more expensive. In Hamburg, "producer gas" containing both CO and CO_2 is used with effect. Hydrocyanic acid gas is particularly lethal, but must be used with caution. Sufficient gas to deal with 1000 cubic feet of space may be got from 5 oz. of potassium cyanide, 1 oz. of sulphuric acid and 2½ oz. of water. On shore, SO_2 gas is frequently used for driving rats out of their holes into the open.

4. *Ferrets* and *terriers* are useful.

Whatever method be adopted, it must be carried out continuously and over very large areas, otherwise the rats will simply migrate to an adjoining district, where they will be left to carry on their practices as before.

Preventive measures.—1. Removal of all waste matters and their rapid destruction. Proper covered metal bins should be used.

2. Proper protection of food—a stout wire netting of not more than ⅛ inch mesh is necessary.

3. Rat-proofing of buildings—cement foundation, protection of all ventilating, etc., openings, proper sealing of drains.

4. Prevention of landing of rats from vessels—4 foot metal discs on hawsers, frequent tarring of ropes, mooring at a short distance from the quay.

The Rat as a Carrier of Disease. (Foulerton, *J. Roy. San. Inst.*, September 1919.)

A high proportion of apparently healthy rats are carriers of one or other of three species of protozoal parasites, without suffering any obvious injury from the infestation. Amongst ninety-eight brown rats caught in London, there were forty-one carriers of trypanosoma lewisi, three of spirochæta icterohæmorrhagica and one of both. The trypanosoma lewisi is found in from 25–65% of rats examined in all parts of the world. It shows but little pathogenicity for any other animal. The spirochæta icterohæmorrhagica is the cause of spirochætal jaundice or Weil's disease. The third parasite is the spirochæta morsus muris, the organism of ratbite fever.

(*a*) Rat Tuberculosis (rat leprosy) is a chronic infective process affecting the skin, subcutaneous tissues and sometimes the lymphatic glands of rats. It is caused by an acid-fast streptothrix. About 5% of rats have been found so infected. The condition resembles avian tuberculosis more closely than any other. As a rule the rat is more or less immune to the human variety.

(*b*) Pseudo-tuberculosis of the rat results from infection with a member of the Colon-Gærtner group. Nodules or tubercles appear in the lungs. Laboratory guinea-pigs and rabbits can be infected, and in them abdominal lesions are mainly found,

infection most probably occurring through food. Similar bacillary pseudo-tuberculosis has been described in poultry, cattle, pigs and sheep. The connection, if any, between them is not clear.

(*c*) Rat Plague. An outbreak of bubonic plague in man is practically always preceded by prevalence of plague amongst rats. It is possible that the rat may aid in keeping the virus of plague alive through the winter in temperate climates.

(*d*) Spirochætal Jaundice (Weil's disease). The spirochæte is present in the kidney and urine of apparently healthy brown rats —the percentage of infected rats varying from 4–40. Infection may be spread either by inoculation or through contaminated food. The latter method would account for the cases that occurred on the Western front during the War. In Japan the disease is endemic, and is found mainly among workers in certain damp coal-mines and workers in drains. It is thought that infection may possibly take place through the unbroken skin. Cases have occurred in this country as well, and milder forms may have been mistaken for simple catarrhal jaundice. The condition is usually an acute one, and diagnosis is made by discovery of the spirochætes in the blood of the patient early in the disease, or in the urine, after centrifugalisation, especially in the third week. The urine has been shown to be infective for forty days.

(*e*) Rat-bite Fever is due to spirochæta morsus muris. In Japan in 1916 some 3% of healthy rats examined were shown to carry the organism. The condition is a mild one, and is due usually to the actual bite of a rat. Possibly, however, contaminated food may play some part. Cases have been recorded where infection occurred after the bite of a cat which a short time before had been playing with a dead rat, and after the bite of a ferret whilst ratting.

(*f*) Trichiniasis. Large numbers of rats caught in abattoirs have been found to be infested by trichina spiralis (21% in knackers' yards, 3% in abattoirs and 0·3% elsewhere in Germany; 76% in a knacker's yard, 100% in abattoirs and 10% generally in Boston, U.S.A.; 3% in the municipal abattoir in Glasgow). As all the embryos do not penetrate the intestinal wall of the host, but are discharged to some extent in the fæces, it is easy to understand how infested rats may contaminate the foodstuffs of other animals, such as pigs.

Typhus Fever.—Till 1869 typhus fever was not distinguished separately in the Registrar-General's returns. For centuries past, the disease has been the accompaniment of famine and war. "Gaol Fever" was another name for the condition, owing to its prevalence in the overcrowded and insanitary prisons of many years ago. A few cases occur from time to time in this country, mainly in Ireland and ports such as Liverpool and

Glasgow. During the War a good deal of typhus was reported from Serbia and among the Austro-German forces. Infection is conveyed by lice (usually P. corporis), and is not otherwise transmitted from man to man. The parasite has not yet been identified, but many observers consider that the bodies known as Rickettsia prowazeki are intimately connected with the disease. These bodies have been found in the intestinal epithelium of lice taken from cases of typhus fever, and are thought to be a phase in the evolution of a protozoon. Somewhat similar bodies have been described as occurring occasionally in the intestinal contents, but never within the intestinal epithelial cells of normal lice. If a louse bites a sufferer during the eruptive period of the disease, it can transmit the virus only from the seventh to the tenth day after the infected meal. This means that a phase of evolution must take place within the body of the louse. Infection may occur either through the bite of the louse or through infected excrement being rubbed or scratched into the skin. It is just possible that the virus may be handed down from one generation of lice to the next.

The incubation period is between five and fourteen days, usually twelve; the rash appears on the fifth day; convalescence sets in about the third week, but the virus may possibly persist in the body for three weeks after the temperature has become normal. This implies an isolation period of some six weeks and quarantine of about twenty-one days. Seasonal prevalence is most marked during the colder months, when lousiness is also greatest, as more clothing is worn and less washing practised. Case mortality in the Serbian Army was 50%, in uncomplicated cases among Serbian prisoners it was 25%. Murchison gave the average rate as 10%, but among older persons the disease is very much more fatal.

Preventive measures are mainly directed against lousiness (see p. 221)—no lice, no typhus fever. Attendants collecting cases from dirty neighbourhoods should wear suitably protective garments. All clothing and bedding should be treated by steam, preferably under pressure.

Malaria.—(Local Government Board Report, New Series, No. 119, 1918.) From September 1917 to the end of 1918, 330 indigenous cases of malaria occurred in this country, and of these sixty-eight were civilians. The cases were more than twice as numerous in 1917 as in 1918. As is well known, the disease is endemic in most tropical countries and in part of the Mediterranean area. Infection was conveyed to this country by troops returning from the various theatres of war. Three species of malaria parasites are known: (1) Plasmodium malariæ, causing quartan fever; (2) P. vivax, causing benign tertian; (3) P. falciparium, malignant or subtertian.

Part of the life of the parasite is passed in the red blood

corpuscles of man, and part in the tissues of the stomach wall and salivary glands of the female mosquito. Two methods of reproduction occur, sexual and asexual. Asexual division takes place in the human host, and a proportion of male and female forms results. When an anopheline mosquito bites a man who has been suffering for some days from malaria, and has these sexual forms in his blood, fertilisation of the female parasite by the male is rendered possible. In about fifteen to twenty days in England (ten days in the tropics) sporozoites are found in the salivary gland of the mosquito, which, when injected into the blood of another human being, will produce an infection similar to that of the patient from whom blood was originally sucked. At a constant temperature of 77° F. the benign tertian parasite completes its cycle in the mosquito in about eleven days, and at temperatures averaging 62·5–68° F. in fifteen days. The lowest temperatures at which the parasite will develop are between 59° F. and 62·5° F., and the time required is fifty-three days.

Three conditions are necessary for the conveyance of malaria: (1) An anopheline mosquito must have bitten a man suffering from malaria at least fifteen days previously (in England). (2) The man must have had in his blood mature sexual forms of the parasite. (3) The atmospheric temperature must have been favourable. These three conditions may be found in any malarial country where a large number of infected persons and millions of anophelines are present at the same time. In England the likelihood of spread is not great. Useful indications of prevalence may be obtained, (1) by catching several hundred female anophelines and, by dissection, examining them for sporozoites in the salivary glands, and (2) by the discovery of enlarged spleens, especially among the child population of any district.

Methods of Prevention

1. Prophylactic quinine is most effective against the sporozoites, hence it is necessary to take the drug at the hours when mosquitoes are most prevalent. A dose of 5 grains in solution about an hour before sunset, followed by another about midnight, is a good rule. The second dose is advisable, as quinine is rapidly eliminated from the blood-stream.

2. Quinine, as a preventive against relapses, means a set treatment course of the drug.

3. Protection against bites is secured by properly arranged nets of at least sixteen meshes to the inch, and special clothing to protect the head, face, neck and hands. In some countries houses are mosquito-proofed by means of non-corrosive wire netting. Imperfectly screened houses are dangerous in that mosquitoes will probably succeed in entering and will remain

long enough to infect all the inmates. Hence hand catching of mosquitoes is necessary in all houses where screening is adopted.

4. Segregation of the healthy by inducing them to live at least half a mile away from the town where malaria is endemic.

Methods of Eradication

1. The discovery and treatment of all malaria cases and carriers is a method particularly applicable to parts of England that may be threatened with malaria at the present time.

2. The elimination of all malaria-carrying mosquitoes (see p. 217).

Yellow Fever is endemic in the West Indies and the adjacent Mexican and South American coasts. Havana, Vera Cruz and Rio are especially affected, and West Africa is also liable to epidemics. The disease is communicated only by the bite of a mosquito, stegomyia fasciata or calopus. To become infected the mosquito must bite a sufferer from yellow fever within the first three days of the illness. The virus must next undergo a period of evolution in the mosquito lasting twelve days, after which time transmission to man becomes possible. Once infected, however, the mosquito may remain so for months. Only the female mosquito is concerned in the transmission of yellow fever. The stegomyia calopus is a domestic mosquito, breeding in the neighbourhood of houses in any collection of water. It tends to remain close to its breeding-place, hence vessels moored a quarter of a mile off the shore are quite safe from attack. The virus is considered to be ultra-microscopic and a filter-passer. There is some evidence that stray native dogs may act as a "reservoir of the virus" (Lagos). The incubation period varies from two to thirteen days (usually three to five), and case mortality is high, up to 75%. Even in tropical climates the disease is most prevalent during the hottest months. Whites appear to be more susceptible than natives. Preventive measures imply an anti-mosquito campaign. Cuba and Havana have been practically freed from yellow fever in this way.

Dengue, or "Breakbone Fever," is another mosquito-borne disease. Culex fatigans was thought to be the mosquito mainly concerned, but stegomyia fasciata or calopus is now considered to be the chief agent in the transmission. The virus, which is apparently a filter-passer, is present in the blood of a patient on the second and third days of the disease—possibly longer. The incubation period is given as five to ten days, and the disease is characterised by rash, severe pains and "saddle-back" temperature. The mortality is negligible, but convalescence is frequently long. The disease is prevalent in tropical and sub-tropical countries

Phlebotomus Fever, or sand-fly fever, is due to the bite of a

tiny fly, Phlebotomus papatasii. It is especially common in the Mediterranean area. The incubation period varies from four to seven days, and the fever lasts three or four days. The blood of a sufferer is infective only on the first day, and apparently the fly cannot transmit the disease till after six days. A fine net with a mesh of twenty-two to the inch is necessary to protect against these tiny flies.

Relapsing Fever is due, in Europe, to the Spirochæta recurrentis of Obermeier. Infection is conveyed by lice, especially P. corporis, probably through their infected fæces or body juices being rubbed into abrasions in the skin. Bed-bugs have been supposed to transmit the infection, but proof is lacking. During paroxysms of the disease the spirochæte may be recovered from the peripheral blood. It has also been found in the sweat and tears. The incubation period is usually from five to ten days; case mortality is about 4%. Similar diseases, caused by slightly different spirochætes, occur in Egypt, India and the United States. Preventive measures should be directed against body vermin of all sorts.

African Tick Fever is a condition akin to relapsing fever, and is caused by spirochæta duttoni. Infection is transmitted through the infected fæces of the tick, ornithodoros moubata.

Trench Fever is another disease conveyed by the body louse. The virus is unknown, but exists in the blood, urine and sputum of sufferers. Infection is transmitted through the fæces or body juices of the louse being rubbed into the abraded skin, and apparently not through the bites. The louse is infective only from the eighth to the twelfth day after feeding on a patient. The virus is said to be ultramicroscopic, but others maintain that Rickettsia prowazeki, mentioned in connection with typhus fever, are the causal agent. In louse fæces the virus resists drying and sunlight and heating to 60° C. for thirty minutes, but is killed at 80° C. in ten minutes.

Tetanus.—The tetanus bacillus is an anærobic organism whose natural habitat appears to be the alimentary tract of horses, cows, etc. For symptoms to be produced the bacilli or their spores must be inoculated through a skin wound. If pyogenic organisms are present at the same time, a condition favourable to anærobic growth is established, and the tetanus bacilli and spores will multiply and develop the powerful toxin which alone is absorbed into the nervous system and accounts for the clinical picture of tetanus. The spores are constantly present in manured land, such as was found generally in Flanders, and in the dust of cities. Some areas always contribute more cases than others. The tropics show a higher incidence than temperate climates. In soil the spores do not multiply, but their resistance is great. Tetanus neonatorum used to occur frequently in the days when aseptic precautions were not adopted in ligature of the cord.

Thorough cleansing of wounds and prophylactic anti-toxin treatment will suffice to prevent the disease.

Leprosy is still a fairly widespread disease, though in this country it has quite disappeared. In India lepers number over 100,000, and in British possessions in South Africa some thousands may be found. In Europe cases occur more especially in Norway, Sweden, Russia, Turkey, Italy and Spain. The disease is due to the bacillus lepræ, which closely resembles the B. tuberculosis. The mode of transmission is uncertain, but, as the bacilli are present in all the leprous lesions, and frequently in the nasal secretions, personal contact or insects are possible means of spread. For the eradication and prevention of the disease strict isolation is necessary. With the growth of modern civilisation in a country leprosy tends to disappear.

The Trypanosomiases are conveyed by the bite of the tsetse fly, either by glossina palpalis or glossina morsitans. The group includes sleeping sickness, nagana in domestic animals, and surra in horses, cattle, etc. There is evidence tending to show that big game act as a "reservoir of infection."

Kala Azar (Leishmaniasis) is a tropical disease, characterised by anæmia and enlargement of the spleen, and due to the protozoal parasites known as Leishman-Donovan bodies. It is suggested that dogs may be "reservoirs of infection," and the dog flea the active agent of transmission.

Cancer

Death-rates per Thousand Living at all Ages—Cancer (all Forms)

	1903.	1905.	1908.	1910.	1914.	1917 (civil pop. only).
Males .	0·733	0·759	0·818	0·856	0·971	(1·263)
Females	1·006	1·011	1·036	1·070	1·161	1·173
Persons .	0·874	0·889	0·931	0·967	1·069	1·210

These rates have been steadily increasing of recent years. Females suffer more from intestinal cancer, males from cancer of the stomach, rectum and alimentary tract from the œsophagus upwards. Cancer of the skin is commoner in males on account of the comparative frequency of involvement of the penis and scrotum. The fact that more females than males die of cancer is due to growths of the breast and generative organs.

It has been said that the increase in the cancer death-rate is more apparent than real, due mainly to improved diagnosis. Of late years it has been customary to divide cancer into growths of accessible and inaccessible regions. Improved diagnosis should be accompanied by a considerable increase in cancer of inaccessible regions. In males, however, the death-rate from accessible

cancer has been increasing more rapidly than that from inaccessible. The opposite has been the case in females, and the total result is only a moderate excess of increase in the death-rate from inaccessible cancer. Thus in nineteen years (1897–1898 to 1916–1917) there has been a 56% increase in mortality from accessible cancer among males and 41% increase from inaccessible. In the same period there has been an increase of 37% from cancer of all sorts amongst males and 12% increase amongst females. The evidence is strongly in favour of a real increase in cancer mortality, amongst males at all events. Cancer is becoming more and more a disease of old age. This is most probably due partly to the fact that with a lowered general death-rate more old people are nowadays alive, and partly to improved and more frequent surgical interference. More cases now die in later life of secondary manifestations. The actual cause of the disease is still unknown. Local irritation appears to have some definite connection, but the popular idea of cancer houses has no foundation. When it is recollected that, on the basis of the Registrar-General's returns for 1911, the chance of a man over thirty-eight years dying of cancer is one in 9·7, and of a woman of the same age one in 7·4, the possibility of coincidence is only too obvious. A cancer district is likely to prove one containing a preponderance of elderly people. It is impossible to state what part heredity plays.

INDUSTRIAL DISEASES

Those due to Poisonous Gases, etc.

(*a*) **Carbon dioxide**—fermentation vats in breweries and wine manufacturies, lime-kilns, etc.; 3% causes dyspnœa, 6% more marked distress, and 10% unconsciousness.

(*b*) **Carbon monoxide**—blast-furnace gases, manufacture (and escapes) of ordinary illuminating gas (7–10% CO), mine explosions, coke-ovens, etc. The gas is odourless. Carboxyhæmoglobin is formed in the blood, with the result that oxygen cannot be carried to the tissues. CO has a much greater affinity for hæmoglobin than has O, and the compound formed is very stable. With about 0·08% of CO in the air the hæmoglobin becomes half saturated, and with 0·16% two-thirds saturated—thus doubling the amount of CO in the air does not necessarily double the degree of saturation in the blood. 0·1% causes symptoms of headache and lethargy within one hour, while 0·3% may produce unconsciousness in twenty minutes.

The symptoms are vomiting, giddiness, headache, ringing in the ears, and great lethargy. Convulsions and coma may supervene, but loss of motor power usually occurs before unconsciousness. If active exercise is indulged in, the rate of saturation increases and poisoning results more rapidly. Should the sufferer

recover, speech is often affected, and mental derangement may follow. Chronic symptoms may be produced by constant inhalation of small quantities of the gas. Post mortem: the pupils are dilated, the blood is bright red, and small hæmorrhages into many of the body tissues may be found.

Artificial respiration and the administration of oxygen are the best remedial measures once the patient has been removed from the poisonous atmosphere.

(*c*) **Ferro-silicon Gases.**—Ferro-silicon is used in the preparation of steel. It is the higher grades containing between 30% and 70% of silicon that are injurious. Exposure to moisture results in the formation of phosphoretted hydrogen and arseniuretted hydrogen, and deaths of seamen have occurred in ships carrying cargoes of this material, especially during periods of stormy weather. It has been advised that the injurious grades should not be used in the manufacture of steel, and that for the storage and conveyance of the dangerous grades special precautions should be taken.

(*d*) **Sulphuretted hydrogen**—old or blocked sewers, chemical works and gasworks—0·2–0·4% may prove fatal. The gas acts on the respiratory centre or else on the ends of the pneumogastric nerves in the lungs. Minute amounts cause symptoms of malaise. With larger percentages sudden death results—as a rule the individual utters a cry and succumbs at once. Fresh air, oxygen and artificial respiration are the best means of treatment.

(*e*) **Carbon bisulphide**—a liquid used as a solvent for rubber and for vulcanising. The latter process is the more dangerous. The vapour given off is very inflammable and very poisonous.

The symptoms of the more advanced degrees of poisoning are staggering gait, great lethargy and loss of appetite. The worker (usually a woman) may fall into a deep sleep on reaching home, and the following day will not become herself again till after inhaling more of the CS_2 vapour. At other times, evidence of excitement or even hysteria appears, or delirium may be produced. Memory may become weakened and speech and muscular power impaired. Neuritis has been noted. Women frequently miscarry. Recovery is usual, but slow.

Work-rooms should be well ventilated, and no naked lights should be permitted.

(*f*) **Benzene** vapour in dry cleaning, and **Petrol** vapour in tank-steamers, may cause symptoms ranging from excitation to coma in workpeople.

(*g*) **Tetra-chior-ethane** was present in the " dope " or varnish applied to aeroplanes. Inhalation of small quantities of the vapour produces general ill-health, but symptoms like those of acute yellow atrophy of the liver, followed by death, may be caused in severe cases.

Proper extraction ventilation appliances near the floor level should be used, and the workpeople employed only for limited

periods in the dangerous rooms. Frequent medical inspection is necessary. Effective varnishes can be obtained which do not contain this poison.

(*h*) **Tri-nitro-toluene** (T.N.T., an explosive). Operatives may be affected with drowsiness, frontal headache, eczema and loss of appetite. Collapse may occur. After continued exposure individuals may develop cyanosis, dyspnœa, vomiting, anæmia and jaundice. Jaundice may at times be profound, and death has occasionally supervened.

Preventive measures include extraction of all fumes, and the wearing of respirators, gloves and overalls. Short work-hours and no overtime should be arranged for.

(*i*) **Tetryl** (tetra-nitro-methyl-anilin, another explosive) may cause troublesome eczema. Headache, drowsiness and loss of appetite have also appeared among workpeople. Protection of the skin and adequate washing accommodation should be insisted on.

Chlorine in bleaching-powder works may cause irritation of the lungs, etc., and even lead to emphysema. **Sulphur dioxide** has the same effect. **Nitric acid** fumes may cause acute congestion of the lungs.

N.B.—A great deal of good resulted in munition factories during the War from the establishment of canteens. In dangerous processes, workers should never commence work without having taken food, as hungry or ill-fed persons succumb more readily. At least half a pint of milk or cocoa should be taken in the morning. Women are especially apt to be careless in food matters.

Disease due to Alteration in Atmospheric Pressure

Caisson disease may be found in workmen employed in an atmosphere of compressed air, *e. g.* in building the foundations of a bridge in the bed of a river. Before the workmen enter the caisson where work is done they pass through the "air-lock," where they are subjected to a pressure which is raised gradually till it equals that in the caisson itself. Before leaving they are slowly decompressed. For every 33 feet of depth in water a pressure of one atmosphere is required to keep water out of the caisson, *i. e.* at 100 feet depth a pressure of three atmospheres or 45 lbs. per square inch must be maintained.

Although unpleasant symptoms may arise during compression, it is during or after decompression that the real symptoms of Compressed-air Illness come on. As a rule, within from a few minutes to several hours after leaving the "air-lock" the man complains of severe pains, known as "bends," in the muscles and joints. These may last for many hours. Paralysis of the legs, retention of urine, abdominal pain, vomiting, vertigo and bleeding at the nose may be noted. It is, however, only in the severe

forms that the spinal cord is affected. The symptoms are probably due to too rapid decompression, whereby the gas, that has been forced into the blood under pressure, tends to reappear as minute bubbles in the vessels and tissues, with consequent loss of function of the areas supplied.

Preventive measures are—

1. Selection of the workmen, excluding all with catarrhs, weak lungs or heart disease. The best age is between twenty and thirty. Alcoholism predisposes.

2. Slow decompression and short working shifts, corresponding with the degree of pressure employed. Hill and MacLeod recommended that for a pressure of 30 lbs. there should be a four-hours working shift and a decompression period of thirty to sixty minutes, and so on, at greater depths lessening the working period and increasing the decompression period. At any rate one minute of decompression should be allowed for every 3 lbs. of pressure.

3. Pure air, cooled if possible, should be supplied to the caisson.

Treatment consists in recompression as soon as symptoms appear, followed by very slow decompression at the rate of three minutes per pound. For this purpose it is advisable to have a medical "air-lock" specially warmed, as decompression is accompanied by a fall in temperature.

DUSTY TRADES are responsible for the group of lung diseases known as pneumokonioses—anthracosis (coal dust), silicosis (stone dust), siderosis (iron dust), and byssinosis (cotton dust). A fibrosis of the lung is produced when the inhaled particles are of a sharp and jagged character. Workers in such trades suffer markedly from diseases of the respiratory system, especially phthisis.

Inorganic Dust

(*a*) **Coal mining.**—On account of the greatly improved ventilation of mines nowadays, coal-miners' phthisis is becoming much rarer, and as a rule miners do not suffer from pulmonary tuberculosis to a greater extent than other occupied males. Backache, nystagmus, due to the eyes looking in an oblique direction in a dim light, and other simple ailments such as dyspepsia are met with. There is, of course, grave risk to life from gas explosions.

"Black-damp" is a mixture of 5–15% CO_2 in nitrogen. By oxidation of sulphide of iron, the O of the air of mines is replaced to some extent by CO_2, with the resulting formation of "black-damp." Death in poisoning from "black-damp" is always due to want of O, and not to the action of CO_2—if there is 75% of "black-damp" in the atmosphere only 5% of O will be present, and this is insufficient to support life.

"Fire-damp" is another name for methane (CH_4)—a mixture of 5–13% in air is explosive. It is not toxic in itself.

"After-damp" is the gas that remains after an explosion in a

mine. Explosions are due either to " fire-damp " or coal dust igniting in the presence of excess of air, and the products are CO_2 and CO. It is to the latter gas that most symptoms of poisoning are due.

Gases formed by certain explosives may contain CO, and peroxide of nitrogen results occasionally from ignition of dynamite or gun-cotton. Acute bronchitis may be caused by this latter gas.

Ventilation of mines is carried out usually by downcast shafts for the entrance of pure air, and upcast shafts for the exit of foul air. The extraction is supplied as a rule by powerful fans in the upcast shaft.

(*b*) **Other Forms of Mining.**

Gold miners on the Rand suffer very much from " miners' phthisis," which is really a pure fibroid disease, any tubercular infection being superadded. Many of the mines are very deep, ventilation is poor, and the temperature is high. A great deal of dust is produced by the rock drills unless water is constantly applied.

Gannister mining causes what is known as " gannister disease," a form of silicosis. The stone is extremely hard and siliceous, and is used, after crushing, for making very resistant firebricks, such as are employed for lining Bessemer furnaces. The grinders suffer even more than the miners, while the brick-makers are least affected.

Tin miners in Cornwall are very prone to fibroid lung with subsequent pulmonary tuberculosis. Ankylostomiasis has also occurred in these mines.

(*c*) **Stone masons** are attacked with fibroid disease of the lung even though their work is mainly in the open air. Tuberculosis frequently supervenes.

(*d*) **Pottery workers** are prone to respiratory diseases, especially pulmonary tuberculosis. " Potters' rot " and " Potters' asthma " are well-known terms. In firing, the china is packed in ground flint, and, subsequently, the flint dust is brushed off, the process being known as " scouring." " Scouring " should be done under a hood with special downward air suction.

(*e*) **Steel-grinding** is done usually by means of grindstones made of either local stone or emery. Emery is composed mainly of an oxide of aluminium, as is also carborundum. Wet and dry processes are employed, and it is the latter which is injurious to health. The workers inhale a mixture of particles of steel and stone dust, and pulmonary disease, especially tuberculosis, is rife among them.

In all these trades much can be done to safeguard the workers by moistening the source of the dust, using special ventilation appliances, and inducing the workers to wear respirators.

Under the Workmen's Compensation (Silicosis) Act, 1918, a Silicosis Order (1919) has been issued dealing with all workers in

mines, quarries, factories, and workshops in which refractory material containing not less than 80% of silica (SiO_2) is got or manipulated. Such occupations include mining and quarrying in flint, gannister, silica rocks, granite, millstone-grit, buhrstone, sandstone, etc.; dressing and grinding of wheels of sandstone, millstone grit and buhrstone; grinding articles on such wheels; dressing and carving of granite, sandstone, etc.; and any processes in pottery manufacture in which powdered flint is used. District M.O.'s are to be appointed by the Secretary of State. They will examine at prescribed intervals all workmen employed in the specified trades, and certify any who may be suffering from silicosis or silicosis accompanied by tuberculosis. Compensation will be paid such sufferers, and, should death supervene, their dependants will receive assistance.

Organic Dust

Cotton workers suffer more from the artificially added moisture in the atmospheres in which they work than from dust. In addition, the temperature is high and the air often impure. The clothes of the workers get wet in such atmospheres, and chills and rheumatism frequently result. The most dusty processes are carding and spinning, while in weaving the moisture is greatest. Dust asthma is occasionally seen.

Flax and **Jute workers** are liable to bronchitis, and a small outbreak of tetanus has been caused in jute workers from infected material. Organic dust is also given off from boxwood during manufacture, in factories where rags are sorted and ground, and in tobacco and snuff works.

Wool sorters occasionally contract anthrax. All cases of anthrax occurring in any workshop must be reported to the Chief Inspector of Factories (see p. 187).

Soot and **Coaltar products** are apt to cause ulcerations and eczematous conditions of the skin.

Flour in milling processes may cause asthma.

LEAD POISONING.—The most dangerous salts as used in industry are the carbonate, the chromate and the oxide. Lead is cumulative and as little as 2 mg. a day, inhaled as dust or fumes, is capable of setting up chronic poisoning. The metal itself is but slightly poisonous. Miners in this country are not affected, but in Australia, where the carbonate is mined, the risk is great.

Smelters suffer inasmuch as the fumes given off contain oxide and sulphate of lead.

Red lead, or the red oxide, is produced by raking molten lead to bring it into contact with the air; the resulting fumes are poisonous. The grinding of the red lead, too, is dangerous, on account of the dust produced.

White lead is made by filling a hut with alternate layers of tan,

pots containing acetic acid, and sheets of metallic lead, and leaving the shed closed for three or four months. Lead acetate is first formed and converted into carbonate by the CO_2 evolved from the tan. The carbonate is finally stripped from the surfaces of the lead plates; this may cause poisoning. So, too, may the process of drying the carbonate in earthenware vessels in stoves. Women formerly were much engaged in this work, but now only men may be employed. Mechanical methods have been introduced, and these have considerably lessened the risk to health.

Pottery Workers.—Lead, as a carbonate or other salt, is contained in many glazes into which the earthenware or china is dipped. The process of dipping and the subsequent smoothing of the ware are dangerous. It has been recommended that a "fritted glaze," *i. e.* a compound of lead, silica, boric acid, etc., fused at a high temperature, should be used instead of raw lead glazes. This would much diminish risk to health. White and cream ware can be glazed just as well without the use of lead, and no glaze should be used which yields to a 0·25% solution of HCl more than 5% of its dry weight of lead calculated as lead monoxide. Young persons and women should be excluded from all doubtful processes.

Lead also enters into the composition of pigments used for decorating earthenware, and poisoning may result.

File-cutting.—This is done by resting the crude file on a bed of lead, and marking it by means of a hammer and chisel. Much lead dust is given off.

Glass polishing is usually done by means of high-speed revolving brushes with constant application of a putty powder containing a high percentage of oxide of lead. A good deal of spray is thrown off, and subsequently the dry putty powder may rise as dust from the floor. Lead poisoning has frequently appeared among such workers. Substitutes for lead putty powder can be found, and at any rate the smallest amount of lead possible should be used in putty powders.

Lead poisoning may also occur in the following trades: Works where yellow chromate of lead dyes are used; enamelling of iron advertisement plates (the stencilling process is especially dangerous), and of pots and pans; filling of electric accumulator plates with red lead; printing (type-founders and compositors may be affected, as type metal consists of an alloy of lead and antimony); plumbing; house painting, during the process of grinding and mixing the colours, burning off old paint, and sand-papering surfaces of new paint; coach painting, etc.

Symptoms of Lead Poisoning

A. **Acute.**—Individuals may be attacked within a few weeks of commencing their work, or persons who have escaped for years

may succumb. Alcoholism predisposes. Severe colic, not always relieved by pressure, may be the first symptom. Bilateral wrist drop or foot drop may follow, and at times the trunk even is paralysed. Acute lead encephalopathy occurs more frequently in women. A toxic hysteria may be the first sign. At all events the woman probably falls down in convulsions while at work. Blindness, paralysis, and insanity may be sequelæ.

B. **Chronic.**—Anorexia, constipation, headache, and a gradually increasing anæmia are the first signs. A blue line, due to the formation of sulphide of lead, may appear at the margins of the gums. Attacks of colic may occur. Peripheral neuritis, especially of the arms, and renal changes may ensue. In women, abortion is frequent, and infants born alive frequently die within the first few months. Chronic poisoning seems to predispose to pulmonary tuberculosis.

Treatment.—For colic, general treatment is all that can be done, so with most of the other symptoms. Latterly an electrical treatment has been introduced. The patient's arms are immersed in one bath, and his feet in another; the positive pole of a battery is placed in the foot bath and the negative in the arm bath, and a current of electricity is thus passed through the body. Lead is deposited especially on the negative pole. The method appears to answer well in chronic cases.

Preventive Measures

1. Non-poisonous paints and processes should be substituted where possible for those which usually cause plumbism.
2. All dust, etc., should be removed by special exhaust ventilation.
3. Mechanical methods should replace handling of poisonous materials.
4. Workers must have every facility for washing their hands and mouths, especially before meals—2 feet of trough or one basin for every five workers, with a constant supply of warm water.
5. No meals should be taken in workrooms. A lemonade made of sulphuric acid is recommended, as an insoluble sulphate is said to be formed in the body.
6. Respirators and overalls may be worn in the more dusty processes.
7. Medical inspection of workers.
8. Exclusion of women and young persons from certain of the processes.
9. Notification of all cases of poisoning to the Chief Inspector of Factories.

The number of cases reported has decreased markedly during recent years, owing to the improved conditions of working.

ARSENIC is employed in the manufacture of certain pigments

used for gloves and textile materials, but to a much less extent than formerly. It is a component of most sheep-dips, and is used for preserving furs. Poisoning has been traced to beer made from impure glucose.

The symptoms are headache, dryness of the throat, redness of the eyes, and general ill-health. Eczema and ulceration of the skin may appear, and a neuritis mainly affecting the lower extremities has been noted.

MERCURY.—Poisoning may result from the fumes given off during roasting of the crude sulphide, or from handling the metal. Barometer and thermometer makers use the metal, and felt hat makers and fur dressers the nitrate. In making pharmaceutical preparations of mercury, in vermilion paint works, and in silvering, gilding and bronzing, poisoning occasionally occurs. The metal volatilises readily at moderate temperatures, hence workmen employed in heated rooms run the greatest risk.

The main symptoms are anæmia, tremor, softening and ulceration of the gums, loosening of the teeth, and fætor of the breath with salivation. Melancholia and loss of power of the limbs may follow. Females tend to miscarry. All cases must be notified to the Chief Inspector of Factories.

PHOSPHORUS.—As sesquisulphide of phosphorus is now used in the manufacture of "strike-anywhere" matches, instead of white or yellow phosphorus, phosphorus poisoning has disappeared among match-makers. By the White Phosphorus Prohibition Act of 1908, it is now forbidden to make, sell or import matches containing such phosphorus. White phosphorus is manufactured from bone ash, and red, or amorphous, phosphorus is obtained from the white variety by exposing it to a temperature of 250° C. in a closed vessel. Red phosphorus is not poisonous, and is used in the manufacture of safety matches.

The clinical picture of anæmia and weakness ending in "phossy-jaw" is never met with nowadays. All cases of phosphorus poisoning must be notified to the Chief Inspector of Factories.

BRASS is an alloy of zinc and copper. "Brass-founders' ague" occurs in men employed in pouring the molten brass into moulds. The symptoms are feverishness, sweating, headache and vomiting. A mild rigor may usher in the attack. There is often tremor and sometimes disturbance of the digestive organs. The indisposition lasts only two or three days. Probably both the zinc and the copper are responsible for the symptoms.

Preventive measures consist in good ventilation, cleanliness, etc.

GLASS-MAKERS suffer a good deal from the effects of the high temperatures necessary in the various processes. Bronchitis and pulmonary diseases are common, but latterly doubt has been thrown on the occurrence of emphysema among such workers.

Indiscriminate use of blow-pipes may result in transmission of such diseases as syphilis; inflammations of the eyes and cataract are met with.

LAUNDRY WORKERS, mainly women, tend to suffer from varicose veins and leg ulcers. Pulmonary tuberculosis is said to be common also, due either to hot, damp, and unhealthy working conditions, or else to infection contracted from handling contaminated handkerchiefs, and such like.

For further information regarding industrial poisonings, the reader is referred to *Diseases of Occupation* (Oliver), 1909; and *Occupations* (Oliver), Camb. P.H. Series, 1916.

NOTES ON VARIOUS ANIMAL PARASITES, ETC.

Trematodes

Schistostomum hæmatobium and **S. Mansoni** produce the condition known as Bilharziasis. The adults of the former live in the portal, vesical, uterine, and hæmorrhoidal veins, and the adults of the latter are found chiefly in the mesenteric veins. The male worm is about ½ inch long, and carries the longer, slender female in a special gynæcophoric canal. The eggs are about 0·16 mm. long, and oval in shape. In the case of S. hæmatobium, the eggs have a terminal spine and are found in the urine, while those of S. Mansoni have a lateral spine and appear in the fæces. The eggs are laid in the tissues and wander about, frequently causing irritation and fibroid change.

If the egg reaches water it becomes a ciliated larva, which dies within twenty-four hours if it cannot enter certain fresh-water snails. In the snail the larva becomes a sporocyst, which in time produces many daughter sporocysts. These finally give off little tadpole-like cercariæ with bifid tails. The cercariæ leave the snail and enter the water, where they can exist for thirty-six to forty-eight hours, within which time they must find a human host or die. An infected snail may discharge cercariæ for weeks on end. Cercariæ enter the human body either through the skin or through the buccal mucous membrane, and are carried to the veins of the liver, where in about two months they develop into sexually mature adults. The condition is prevalent in South and North Africa, Persia, Arabia, etc. Symptoms appear at least three months after infection in the case of S. hæmatobium, and in from four to eight weeks in S. Mansoni. There is usually blood in the urine, or ulceration of the rectum with diarrhœa. The liver and spleen may become enlarged, and anæmia is often severe. As the cercariæ die within forty-eight hours if no human host is found, water is safe after that time. Acid sodium sulphate (1–1000) or filtration through Pasteur Chamberland candles is advised.

Liquor Cresol. Sap. (1–10,000) immediately renders water safe for bathing.

Fasciola hepatica (Liver fluke) is leaf-shaped, about 1¼ inches long, and has two suckers on the ventral surface. It is found principally in ruminants, very rarely in man, and its habitat is the bile ducts. Fibrotic changes occur, due to its presence, and the condition known as "pipey liver" is produced. The eggs, which have an operculum at one end and contain a ciliated embryo, are passed in the fæces. The embryo, after hatching, enters water and finally bores its way into a snail (Limnea truncatula). Here cercariæ are formed, and these finally leave the snail and become encysted on blades of grass. They are eaten by sheep, and the cycle is thus completed.

In China, Japan, and Formosa, another species of fluke affects the lungs of human beings, causing rusty sputum and symptoms not unlike pulmonary tuberculosis. In these countries, too, a form of liver fluke is quite common in man.

Cestodes

Tænia Solium.—The adult worm is 6–12 feet long, and is found in the intestine of human beings. The head has four sucking discs and a double row of hooklets. The segments are about 1 cm. long by 7–8 mm. broad, and each has male and female generative organs. The ripe segments pass out in the fæces and may be eaten by an intermediate host, or they may expel their ova when passed. The ovum contains a small embryo with six hooklets. To complete the cycle the ovum must be swallowed by a pig (occasionally sheep or dog) or man. The eggshell is then digested and the embryo set free. It bores its way into the liver, muscles (tongue, neck, shoulder and diaphragm of the pig), brain, eye, etc., and, loosing its hooklets, develops into a bladder-like cysticercus (or larval stage), with an invaginated head or scolex, armed with hooklets. These cysts are usually the size of a pea, but in the brain may be considerably larger. Pig flesh infected in this way is known as "measly pork." Man is usually infected by eating such meat, and it must be remembered that man is liable to harbour both the adult worm and the cysticercus stage; in the former case he will probably have eaten insufficiently cooked pork and in the latter he will have swallowed ova, passed perhaps even in his own fæces. The condition is fairly common in North Germany, but rare in this country. Cysticerci have been found alive four weeks after slaughter of a pig, hence it is doubtful if cold storage is protective. Only thorough cooking should be relied on.

Tænia Saginata.—Man is the host of the adult worm, which is usually from 15–20 feet long. The head is larger than that of T. solium and measures about 2 mm. square. It has four sucking discs, but no hooklets. The segments or proglottides have

fifteen to thirty lateral uterine branches, whereas those of T. solium have rarely more than ten. The egg contains a six-hooked embryo, which is freed from its covering shell when ingested by the ox, in the muscles and liver of which the cysticercus stage takes place (" measly beef "). The cysticercus is smaller than that of T. solium, contains less fluid, and has an unarmed scolex. If man eats such beef imperfectly cooked the cycle is completed, the adult worm with sexually mature segments developing in about two months. The condition is common in this country and in North America. As the cysticerci die within three weeks of the slaughter of their host, cold storage is probably a safeguard. Salting is also said to be protective.

Tænia Echinococcus.—The adult worm, 4–5 mm. long, and consisting of only three or four segments, is found in the intestine of the dog. The head has four sucking discs and a double row of hooklets. Only the terminal segment is mature. The eggs may be consumed by sheep, pigs, oxen or man. The six-hooked embryo is then liberated and bores its way into the peritoneal cavity or the muscles. It frequently enters the portal veins and is carried to the liver, or it may pass to the lungs or brain. In any of these places it may spend the cysticercal or larval stage, losing its hooklets and developing an external laminated and an internal germinal layer. It is filled with clear fluid, and in the course of time brood-capsules may grow from the germinal layer. On these the scolices (really complete heads of T. Echinococcus) develop, and each scolex is capable of growing into the adult worm if eaten by a dog. The parent cyst may have daughter cysts growing out of it and these again grand-daughter cysts, so that from one embryo thousands of larval worms may be produced. This cystic form is known as a hydatid cyst. Dogs tend to become infected in such places as slaughter-houses, and man may be infected when he lives in close association with dogs, as in sheep-farming countries.

Dibothriocephalus Latus.—The adult form may be 30 feet long, and is found in the intestine of man. It has been observed also in cats and dogs. The larval stage is passed in the peritoneum and flesh of certain fresh-water fish, such as pike, perch and salmon. The head of the worm is almond-shaped, with two lateral sucking grooves but no hooklets. Each segment has a rosette-shaped uterus. The eggs show an operculum at one end and contain a ciliated embryo. This embryo is set free in water and enters a fish. It is not known whether the embryo passes through any other animal (*e. g.* water snail) before entering the fish. The larva remains encysted till eaten by man, when the cycle is completed. In man severe anæmia is produced, due, it is said, to a hæmolytic poison contained in the head of the worm. Salting and smoking are not supposed to kill the larvæ. Fish are probably infected through contamination of water with sewage. The countries

mainly affected are Russia, Scandinavia, Switzerland and Japan.

Nematodes

Trichina Spiralis.—The adult form lives in the small intestine usually of rats, frequently of pigs and occasionally of man. The female is 3–4 mm. long and the male 1·5 mm. Each female can produce about a thousand embryos, and these are deposited directly in the lymph spaces of the intestinal wall, whence they pass to the blood-stream and so to the muscles. They enter the primitive muscle fibres and in from two to six weeks develop into encysted larvæ. These larvæ are about 1 mm. long, have a pointed mouth end, and lie coiled up in the tiny cysts. There may be as many as four in one cyst. In the course of time the cyst wall becomes fibrous, and calcification may set in; this takes up to six months in man, but very much longer in the pig. Encysted larvæ may remain alive for twenty-five years. For the cycle to be completed the raw or imperfectly cooked flesh must be eaten by another animal. The liberated embryos then enter the small intestine, become sexually mature about the third day, and on the seventh day the embryos will probably be discharged by the female. It takes about another week for the migration of the embryos to the muscles to complete itself. The male worm dies after copulation and the female usually disappears from the bowel in about six weeks. In the pig the muscles most frequently affected are the diaphragm, shoulder muscles and tongue. The capsules, if calcareous, may be felt at times as gritty points in the flesh, and they may be examined under a low power of the microscope if a piece of the flesh is pressed between two glass slides. A little acetic acid may be used to dissolve any lime salts present. In man severe symptoms may appear. Gastro-intestinal trouble may occur when the adults are breeding in the bowel and, during the migration of the embryos, severe muscle pains, fever and œdema are frequent. The blood usually shows an excess of eosinophiles. Diagnosis is best made after examination of a small portion of the deltoid muscle. The disease is not common in this country, but in America from 1–2% of pigs are said to be infected. The best preventive measure is thorough cooking of all pork—a temperature of 160° F. is fatal. Salting, pickling and smoking, unless done very thoroughly, are not safeguards. The larvæ die in twenty days if kept at a temperature below 5° F., hence, very cold storage is effective. Rats should be excluded from all slaughter-houses, piggeries, etc.

Ankylostoma Duodenale.—The adult male is about 10 mm. long, and the female 10–18 mm. They are whitish in colour and are found in the intestine of human beings, especially in the jejunum, where they attach themselves to the mucous membrane by means of hooked teeth. The eggs are about 50–60 μ in length

and, when passed in the fæces, usually show four segments. Further development is aided by moisture, supply of air, and a temperature of 80–90° F. Under such conditions a small embryo appears coiled up inside the egg in twenty-four hours, and within a week it is hatched out as a larva. The larva passes through a series of moults before becoming " ripe." It is then very active and resistant and may live in damp ground for months. The " ripe " stage may be reached in four to five days and is the infective one for man. The larvæ enter human beings directly through the mouth by means of infected food, drink or hands, or through the hair-follicles of the skin. In the latter instance they pass into the veins and, on reaching the lungs, they enter the air-cells. From there they ascend the trachea and descend the œsophagus to the stomach and intestine. This occupies seven to ten days. Within about two months of the larvæ reaching the intestine eggs appear in the fæces. The main symptoms are anæmia, due to the sucking of blood by the worms, and probably also to a hæmolytic substance excreted by them, joint-pains, lethargy, dyspepsia and œdema. Discovery of the eggs in the fæces is the only sure method of diagnosis. Preventive measures are: personal cleanliness, protection of the feet by boots and attempts to free carriers of the worms. Thymol and oil of chenopodium are successful drugs in treatment. The disease is common in the zone lying between 36° north and 30° south of the equator. It has been met with in Cornish tin-miners.

Ascaris lumbricoides, or common round-worm, lives usually in the upper portion of the small intestine. It is found usually in children, and may cause itching, convulsions and anæmia. The male is 4–8 inches long and the female 7–12 inches. The eggs are oval, brownish in colour, and usually have a rough exterior. The embryo does not develop till about a month after the egg has been passed; till then it is not infective for human beings. The embryo remains in the egg till ingested. There is no intermediate host.

Oxyuris vermicularis, or thread-worm. The male is about $\frac{1}{16}$ inch long and the female about $\frac{1}{2}$ inch. After copulation in the small intestine the male dies and the female descends to the large bowel. The worms frequently escape from the anus. The egg contains a coiled-up embryo, and infection occurs probably through infected hands, water, vegetables, etc. There is no intermediate host. The condition is commonest in children.

Trichuris trichiura, or whip-worm (so-called from its thick body and slender neck), is found usually in the cæcum of man, with its neck buried in the mucous membrane. It is about 2 inches long. The eggs are oval in shape with a projection at each end, and are very resistant. The future development of the embryo is the same as in ascaris. No intermediate host is necessary. Few, if any, symptoms result from this condition.

Leeches are found in water and may attach themselves to

the pharynx, nose, etc., of human beings. Severe hæmorrhage may result. The young leech is small and may remain attached to a mucous membrane for some time, till it reaches adult size and produces symptoms.

Filariæ

Dracunculus medinensis, or guinea-worm. The male is about 1 inch long and the female from 1–3 feet. The two sexes copulate in the mesentery. The male then dies and the female passes head-first down the connective tissue of the leg. In the lower part of the leg a small blister appears and, when this bursts, the head of the worm is seen in the centre. Myriads of minute coiled embryos in a milky fluid are discharged whenever the part containing the worm is immersed in cold water. It is thought that this downward movement of the impregnated female is due to the search for water. In water the embryo can survive for two to three weeks, till it finds a variety of cyclops, into which it penetrates. Here it develops, and may remain alive for about six weeks. Infection in man occurs through swallowing water containing the cyclops. Preventive measures consist in boiling all drinking water, or careful filtration. The condition is met with especially in Africa and the East Indies.

Filaria Bancrofti (F. sanguinis hominis).—The adult male is about 2 inches long, and the female 3 inches. They live in the lymphatics and glands of man. The embryos are minute and enclosed in an almost imperceptible sheath. During the night these embryos enter the peripheral circulation through the capillaries, during the day they remain in the lungs and larger arteries. If the individual alters his habits and sleeps during the day, the embryos appear in the peripheral vessels during the day-time. This phenomenon is apparently connected with the life-cycle of the parasite, for the disease is transmitted by the mosquito, culex fatigans. This mosquito sucks the blood of an infected person during the night and the embryos enter its stomach. They then pass through a period of development lasting fifteen to twenty days in the muscles of the mosquito, and finally migrate to the base of the proboscis, where they remain till the mosquito bites another human being and so transmits the infection. Symptoms produced are lymph-scrotum, elephantiasis, hæmato-chyluria, etc. Anti-mosquito measures are preventive.

MOSQUITOES "are small, two-winged insects, with a slender body and long, delicate legs, having the body and wings covered with scales and the head, in the female, provided with a strongly developed piercing proboscis, whilst in the male, in addition to a slender proboscis, a number of very hairy appendages are present which give the head a feathered appearance." Midges (chironomidæ) are frequently mistaken for mosquitoes, but may be distinguished by absence of the biting proboscis.

Life-history.—There are four states: (1) egg, (2) larva, (3) pupa, and (4) adult mosquito or imago. The first three are aquatic. The eggs (about 1 mm. long) are laid on the surface of water either singly or in rafts; they float, as they are provided with air-cells. In two to three days the eggs hatch out into larvæ, which come to the surface of the water to rest or breathe, but at other times move rapidly about with a wriggling motion. The larva passes through several moults, and in about seven to ten days becomes a pupa, like an exaggerated comma. This stage, which may last about seven days, is passed without food and at the surface of the water. At the end of this time the pupal case splits and the adult mosquito, some ½ inch long, emerges. From egg to adult occupies usually two to three weeks, but the influence of atmospheric temperature is marked. It is the females that suck blood, as apparently blood is necessary for the proper development of the eggs. Each female can lay between 100–200 eggs at a time and more than one batch may be laid. With a favouring wind mosquitoes may travel several miles.

Varieties.—Two main groups must be distinguished: (*a*) Anophelines, *e.g.* A. maculipennis and A. bifurcatus, which transmit malaria; (*b*) culicines, which are mostly harmless, but which may transmit yellow fever (Stegomyia fasciata) and dengue and filariasis (Culex fatigans).

The main points of difference are—

	Anophelines.	Culicines.
Adults—		
Resting position	The body and head in a straight line, forming a distinct angle with the roof, wall, etc.	Head and body parallel with the surface.
Wings . .	Frequently spotted.	Usually plain.
Palpi . .	As long as the proboscis in both sexes, but not plumed in the female.	Very short in the female, like two small knobs.
Eggs . . .	Laid singly.	In rafts.
Larvæ . .	Small head. No respiratory siphon. Lie flat along the surface when they breathe.	Large head. Long respiratory siphon. Hang head downwards when they breathe.

The principal anophelines found in England are A. maculipennis and A. bifurcatus. Both can transmit the malaria parasite. The former is the one most frequently found in houses, and during the winter the species is continued by the survival of fertilised females in cowsheds, cellars, etc. A. bifurcatus appears to bridge over the winter in the larval stage. Cases of primary malaria have occurred in England since the beginning of 1917, more

especially in the Isle of Sheppey and the adjacent region between the Medway and the Thames, and in the neighbourhood of Sandwich, on the Kentish coast.

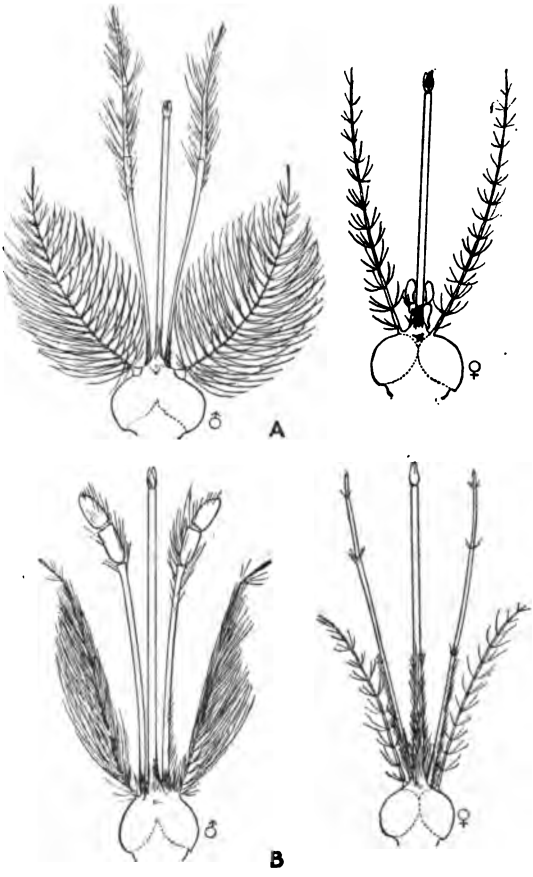

Fig. 17.—A, Heads of male and female Culicina. B, Heads of male and female Anophelina (after Giles).

Anti-Mosquito Campaign

1. **Adults**—

(*a*) Hand-catching with nets, etc., inside houses.

(*b*) Removal of vegetation where mosquitoes hide during the day.

(*c*) Catching in traps, of which various types are recommended.

(*d*) Fumigation with SO_2 (2 lbs. of S per 1000 cubic feet) or spraying with a weak solution of formalin. Most effective during hibernation.

2. **Larvæ**—

(*a*) Abolition of possible breeding-places.

(*b*) A weekly emptying and drying of all household water vessels and any pools in the vicinity.

(*c*) Covering over collections of water, *e.g.* storage tanks. If net is used, the mesh should be eighteen to the linear inch.

(*d*) Application of larvicides to collections of water, *e.g.* a mixture of crude oil and kerosene if spread over the whole surface in an unbroken layer. One teaspoonful of commercial cyllin per gallon of water kills larvæ in a few minutes and pupæ in less than half an hour.

(*e*) Proper drainage of marshy areas and "filling" operations.

(*f*) Clearing vegetation out of pools and making the edges hard and smooth. This renders pools inimical to larvæ.

(*g*) Stocking ponds with larvæ-eating fish, *e.g.* sticklebacks, top minnows, gold-fish. This method is useless unless vegetation is removed from the pool.

3. **Eggs**—

The edges of streams and pools should be sprayed, with *e.g.* cyllin, as eggs may be deposited in such places. Artificial breeding-places may be placed in suitable spots and the eggs and larvæ killed every sixth day.

It is obvious that measures directed against the breeding of mosquitoes are likely to give more satisfactory and permanent results than the killing of a few adults. In cases where it is impossible to deal with the problem at its source, houses should be made as mosquito-proof as possible and nets (eighteen meshes to the linear inch) should be employed—*vide* Malaria, p. 197. (L.G.B. Report, New Series, No. 119, 1918.)

PHLEBOTOMUS PAPATASII conveys the infection of sand-fly fever in the Mediterranean area, India, etc. It is a tiny midge about the size of a pin's head and very hairy. It passes through the stages of egg, larva and pupa before reaching adult form, the whole cycle occupying six to twelve weeks. It is found in all stages in holes and crevices where moisture is present. The winter is passed in the larval stage. The female sucks blood before ovipositing. The range of flight of the adult is very small. To protect against this insect a net with a mesh of at least twenty-two to the inch must be used.

STOMOXYS CALCITRANS, or biting stable fly, is like the ordinary house-fly, but possesses a biting proboscis. It has been credited with transmitting the virus of poliomyelitis, but proof is lacking.

GLOSSINA PALPALIS, or tsetse-fly, carries the trypanosome of

sleeping sickness in tropical Africa. It possesses a short proboscis and is peculiar in that it deposits a fully formed larva.

MUSCA DOMESTICA, or common house-fly, forms 90% of all flies caught in houses. The adults become sexually mature in ten to fourteen days, and the female begins to oviposit four days after mating. Eggs are laid in batches of 120, and four such batches may be laid by one female in a season. The favourite site is on the surface of fermenting vegetable matter or filth of any sort provided it is moist. Each egg is about one mm. long, white, shiny and cigar-shaped. The larvæ or maggots appear in from eight hours to four days, according to the temperature. They are about $\frac{1}{14}$ inch long and whitish, with a pointed head and rounded posterior. They are very active, and begin to burrow at once. In five to eight days, after two moults, they become full grown (about $\frac{1}{2}$ inch long). At this stage they are found usually a few inches below the surface of the refuse. They now leave their feeding-ground and seek a drier spot, frequently in the surrounding earth or at the top or sides of midden walls. Here in the course of five to seven days they develop into cylindrical pupæ of a chestnut colour. At the end of this time the flies emerge and make their way to the surface, if the pupæ have developed below ground. The wings are crumpled at first, but in little more than an hour the flies are capable of flight. From egg to adult fly occupies about ten days as a rule. The total range of flight is at any rate one mile.

Flies feed on filth of all sorts, and may convey infection in various ways. They deposit vomit and fæces on everything on which they alight. In addition, when feeding on solid material they attempt to soften it by means of vomit and saliva. Pathogenic organisms may survive in the crop for several days and thus infect the vomit. Their fæces, too, may be dangerously infected. Flies may also carry various organisms on the hairs, especially of the legs; such organisms may survive for several hours. In these ways many diseases may be spread abroad, *e. g.* typhoid and para-typhoid fevers, epidemic diarrhœa, the dysenteries, and possibly cholera, anthrax, tubercle and various other infective disorders.

Preventive measures—

1. Removal of all refuse, etc., from the neighbourhood of dwellings. What cannot be removed at once should be covered over. This will abolish breeding-places, and is the most important measure.

2. Proper storage and protection of food. This makes feeding less easy within doors and prevents infection.

3. Destruction of flies—

(*a*) Tangle-foot traps—wires or papers smeared with a mixture of well-boiled castor oil and resin in the proportion of five to eight. Various other traps have been devised and answer well.

(*b*) Poisons such as a mixture of milk 20%, formalin 3%, and lime-water 77%, sweetened with sugar. A good plan is to soak pieces of bread in this and expose them in suitable places.

(*c*) Hand-killing by means of "swatters."

4. Destruction of larvæ in manure—

(*a*) By close-packing the manure and relying on the heat of fermentation to destroy the larvæ (50° C. kills in three minutes).

(*b*) Trapping the migrating larvæ in special gutters.

Huge numbers of flies are said to die in autumn of a parasitic disease due to a fungus, empusa muscæ.

Blue-bottle Flies (calliphora) and **Green-bottle** (lucilia) can possibly infect food in much the same way as the house-fly. During the War they frequently caused myiasis of wounds.

LICE—

Pediculus corporis or **vestimenti** lives on the body or clothing of its human host. The female lays some 120 eggs within about a fortnight, attaching them by a sort of cement to fibres of the clothing, especially around seams. Occasionally they may be laid on the pubic or axillary hairs. The eggs are yellowish, glistening and about the size of a pin's head. They hatch out in eight to twelve days into what are really small editions of the adults. These moult several times and become sexually mature in about two weeks. Lice may live a week without feeding, and the eggs or nits may retain their vitality for a month in clothing that has been laid aside.

Pediculus capitis usually remains in the head, but may be found on other parts of the body. The female attaches its eggs to the hairs of the head.

Phthirius pubis, or crab louse, lives in the neighbourhood of the pubis and anal region and deposits its eggs on the surrounding hairs. It is difficult to detect, but frequently bluish-grey spots on the skin give an indication of its presence. The life-histories of these two species are much the same as that of the body louse.

How to distinguish the adults—

	Pediculus Corporis.	Pediculus capitis.	Phthirius pubis.
Site . .	Body and clothing.	Head.	Pubis, etc.
Size . .	About $\frac{1}{5}''$ long.	About $\frac{1}{8}''$ long.	About $\frac{1}{25}''$ long, broad and squat.
Abdomen .	Eight segments. Not hairy.	Seven segments. Hairy sides.	Six segments. Hairy sides.
Other points .	Bite more irritating.	Colour often dark, especially in dark hair.	The second or third pairs of legs have strong, bent claws.

Lice cause considerable irritation, especially in persons who have no means of changing their clothing or of bathing frequently. They produce a state of lowered vitality on account of loss of sleep, particularly among young children, and skin diseases such as impetigo may be due to their presence. Pediculus corporis conveys the infection of typhus, relapsing fever and trench fever.

Disinfestation.—The individuals infested and their clothing must be dealt with at the same time. Thorough bathing of the body and head and shaving the hair of the pubis, chest and axillæ should remove the lice and nits. It is usually impossible to cut short the hair of school-girls. In such cases it is advisable to wash the head thoroughly in the first place, soak it with paraffin, and roll the hair up turbanwise in a towel all night (avoiding naked lights). In the morning wash thoroughly again and comb carefully with a fine toothcomb. Dilute acetic acid (10%) may be used as well to remove nits.

Clothing may be dealt with by (1) Heat, either steam or hot air (Lice and nits are killed by exposure to 60° C. for fifteen minutes); (2) soaking in 2% lysol for twenty minutes.

FLEAS.—Pulex irritans is the flea that most commonly attacks man. Xenopsylla cheopis is the rat flea that conveys the bacillus of plague from rat to man. The eggs are large and laid singly. They fall on the ground, and are found especially where domestic animals sleep. In two to four days in summer, and in about two weeks in winter, they hatch out into whitish, footless, slightly hairy larvæ. The larva feeds on the organic matter in the dust of the floor, and is full grown in about a fortnight. It then spins a cocoon and becomes a pupa. At the end of another two weeks the adult emerges.

When the rat flea sucks plague-infected blood the bacilli multiply in its stomach, and the mass of bacilli finally blocks the œsophagus. A flea in this condition, when it endeavours to suck more blood, regurgitates some of this infected material on the skin of its host. In this way the bacilli may enter through the bite. The organisms are also found in the fæces of the flea, and may be rubbed into the puncture wound. Rat fleas have been known to remain infected with B. pestis for forty-three days.

Destruction of fleas.—Close all the windows, etc., of the room, sprinkle naphthaline everywhere, spray with 5% formalin and leave the room closed for a day or two. Then shake all mats in the room and collect and burn all the dust. Finally wash with 5% formalin or 1 in 1000 perchloride of mercury solution.

CIMEX LECTULARIUS, or bed bug. During the day bugs usually remain hidden in cracks in the walls, floor, beds, etc. Eggs are laid in small clusters and attached to the sides of such crevices. They hatch out into larvæ in six to ten days. These

larvæ resemble the adults, and after moulting several times become full-grown bugs within about six weeks of the hatching of the eggs. In another two weeks they are sexually mature. Bed bugs can live for eight to nine months without food.

Destruction.—Rooms may be fumigated with sulphur, 3 lbs. per 1000 cubic feet. Hydrocyanic acid gas is very effective, but has to be carefully handled. All surfaces should subsequently be well scrubbed, and powdered naphthalene may be dusted into all cracks and corners. A painter's blow-lamp may be rapidly passed over possible hiding-places—if done quickly this will not injure furniture, etc.

SARCOPTES SCABEI, or itch insect. The female burrows into the skin as far as the malpighian layer, depositing eggs as she goes, and in two or three months dies at the end of the tunnel. About twenty-four eggs may thus be laid. In about seven days the eggs hatch into larvæ, which moult and become nymphs in sixteen days. In another five days the insects are sexually mature; the females become fertilised and the males die. The whole cycle is completed in four weeks. The nightly irritation that is such a marked feature of scabies is said to be due to the young females moving over the surface of the skin. The condition is due to lack of cleanliness, and special treatment, such as sulphur ointment inunction and thorough disinfestation of all clothing are required before the parasites and their eggs can be killed.

(Much of the matter in this section has been taken from *Memoranda on Medical Diseases in the Tropical and Sub-Tropical War Areas* 1919. H. M. Stationery Office.)

ISOLATION HOSPITALS

The site should be convenient of access and as central as possible, but a populous area is to be avoided. Main water supply and sewerage should be aimed at, otherwise a sufficient supply of wholesome water must be provided (40–50 gallons per head per day), and arrangements made for the land treatment of sewage. In addition, the site should be open and healthy (south-east slope best), with a dry sub-soil, and not too steep. The area should rarely be less than two acres, and the liklihood of future extension should always be kept in mind. A wall at least 6 feet 6 inches high should enclose the site. It is advisable to allow a 40 foot space between the wards and the boundary wall. The number of patients should never exceed twenty per acre (L.G.B. requirements).

No isolation hospital should contain less than twelve beds. Should these meet more than the requirements of one district, then the district should unite with one of its neighbours to erect a combined hospital. A very small hospital costs nearly as much to construct and to maintain as one considerably larger.

It is usually stated that one bed for every thousand population is necessary, in addition to special accommodation for small-pox cases. It is well to erect an administrative block rather larger than immediate requirements demand, as it is more difficult to find accommodation for an increase in staff than for an increase in the number of patients. The administrative block in smaller hospitals may be placed at the entrance gate, but in larger institutions it is better to have a proper porter's lodge, with which may be combined a visitors' waiting-room and patients' discharge-rooms. In any case, space should be left for future addition to the administrative block and, if nurses' rooms are included in this building, special quarters should be set aside for night nurses. Ward-blocks should face north-west and south-east, and the space between blocks should be at least twice the height. A glass-roofed verandah on the sheltered side is an advantage. One-storey pavilion wards are best, and there should never be more than two storeys. In a hospital of any size male and female wards must be provided for each disease it is proposed to treat. Covered ways, open at the sides, may connect the various blocks. Wards should not, as a rule, have more than twenty beds. Each bed should have 12 feet of wall space, 144 square feet of floor space, and 2000 cubic feet of air space. The usual dimensions of a ward are 26 feet wide, 13 feet high, and 120 feet long (if twenty beds are to be accommodated). One square foot of window, including the frame, should be provided per 70 cubic feet of space. Windows should be placed on each side of the wards and should extend from about 3 feet 6 inches above the floor to within 1 foot of the ceiling. Hoppers with side checks are usually provided in the upper 2 feet of window. Wall air-inlets are sometimes placed beneath each bed and behind each radiator. Heating is usually maintained by hot-water radiators and open fires. Electric lighting is best, and a wall plug for every bed is advisable. Walls should be lined internally with some hard washable substance such as Keene's cement. Distempered plaster is cheaper and fairly satisfactory if the distemper is renewed sufficiently often. All angles should be rounded off. Floors may be made of teak or oak, well polished. Composition floors are good, but are liable to crack. The sanitary annexes should be separated from the wards by cross-ventilated passages. Preferably two bracket wash-down closets should be provided for every large ward, as well as a bed-pan slop-sink with special flush.

About 20% of the total beds should be isolation beds. Half of them should be in single-bed wards, and four to six bed wards for cases of mixed infection, and the other half should be cubical isolation wards for cases of doubtful diagnosis. It is advisable to attach an isolation ward containing one or two beds to every large ward. *Cubicle wards* are of three types—either completely separated and entered from a verandah, or completely separated

but entered from a central passage, or separated by partitions extending to a height of 6–8 feet from the floor and entered from a central passage. The dividing walls are frequently made of glass, as this renders supervision easier. When the cubicles are entered from a central passage the doors should not be placed opposite one another. Each has its own wash-hand basin and nursing and medical appliances. As certain existing hospitals have insufficient isolation accommodation, various devices have been adopted to overcome the difficulty. The "*inunction system*" was used in the treatment of scarlet fever. It consisted in coating the patient with eucalyptus oil every night and morning for the first four days, and then once a day till the tenth day. In addition, the tonsils and nasopharynx were swabbed with 1 in 10 carbolic oil every two hours for the first day. The cases were nursed in general wards, but the procedure is of doubtful utility. For diseases of low infectivity the "*bed isolation*" system has at times been advocated. Cases suffering from different infectious diseases are all nursed in the same ward, but each case has its own utensils, and rigid precautions are taken to prevent cross-infection. Success has not always attended the practice.

Other buildings required in an isolation hospital are special receiving-rooms and discharge-rooms, laundry with boiler-house and engine-room, disinfecting chamber, mortuary and ambulance shed. A small destructor is useful for dealing with infected material of all sorts.

Isolation hospitals are best made of substantial structure. Buildings of a temporary character, as for instance those made of wood and corrugated iron, have never been favourably viewed by the L.G.B. They are hot in summer, cold in winter, difficult to keep weather-proof, and liable to be destroyed by fire. Furthermore, when the site has been prepared, water and drainage arranged for and furnishings purchased, it frequently happens that the difference in cost between a temporary and a permanent structure is very little indeed. The main advantage of such buildings is that they can be erected very rapidly, and this may be of importance during an epidemic. It is unnecessary to state that isolation hospital accommodation should be arranged for during inter-epidemic periods, so that everything may be in readiness for the reception of cases should a serious outbreak of infectious disease occur. Temporary buildings are to be preferred where large numbers of persons are collected together for short periods of time, as in the case of hutment camps and large works of a temporary character. Finally it is possible to increase existing permanent accommodation by means of temporary structures, *e. g.* tents, during big epidemics.

(*a*) *Tents.*—A bell-tent has a capacity of some 500 cubic feet and can accommodate one patient. The regulation hospital

marquee, with a capacity of some 3,300 cubic feet, can hold three cases. Other varieties exist.

(*b*) *Portable huts* are usually made in sections, with framework and external wall of wood and an internal lining of canvas, Doecker material, or asbestos composition.

It is a good plan to have concrete platforms laid down in readiness to receive these tents or huts. Warming is best arranged for by slow combustion stoves.

Small-pox hospitals.—As small-pox patients bear removal very well, there is no need to select a site in close proximity to a populous district. The L.G.B. requirements are—

1. The site must not have within a quarter of a mile of it a hospital, workhouse, asylum or any similar institution, or a population of 200 persons.

2. The site must not have within half a mile of it a population of 600 persons, either in institutions or dwelling-houses.

3. A small-pox hospital must not be used at one and the same time for the reception of cases of small-pox and persons suffering from any other disease.

The number of beds to be provided will vary greatly according to the locality. A standard of 1 per 3000 population has been suggested. It is in small-pox hospitals that special use is likely to be made of temporary structures for extension in case of emergency.

DISINFECTANTS

A disinfectant is a germicide, an antiseptic merely inhibits growth and does not necessarily kill. A deodorant may remove smell either by altering the chemical composition of the substance with which it is in contact, or by substituting its own odour for one that is less desirable. It is not necessarily a disinfectant or an antiseptic.

The coal tar disinfectants, made by the distillation of coal tar, consist of thick fluids containing tar acids such as phenol, cresol, and other phenoloid bodies. Those which form solutions when mixed with water are essentially the sodium and potassium salts of the various phenols. Those which yield emulsions are composed of the phenolic acids and soap, oils, resins, or gelatine. The higher homologues of phenol, cresol for example, are more efficient as germicidal agents than phenol itself, and much less poisonous. Many of the commercial coal tar disinfectants are practically free from phenol, and consequently are relatively non-poisonous.

Emulsions are more germicidal than solutions on account of the Brownian movement they exhibit when mixed with water. The bombardment which goes on between the emulsified particles and the organisms results in the quicker and more effectual appropriation of the germicide by the organism. As heat accelerates the vibratory velocity, it is this which probably explains

the increased efficiency which emulsions have when used hot. Izal and cyllin have a Rideal-Walker carbolic acid coefficient of about twenty. This implies that a dilution of 1 in 400 of izal or cyllin in water possesses the same disinfecting value as 1 in 20 phenol. For general use a 0·5% solution of izal or cyllin is employed. Lysol is a saponaceous fluid containing about 50–60% of cresol. It has a carbolic acid coefficient between 5 and 10, and is commonly used in 1% solution.

The requirements of a coal tar disinfectant include the following: It should be relatively non-poisonous and possess a high germicidal efficiency, not materially reduced in the presence of organic matter. It should not separate out into layers, and should be miscible with both hard and soft waters. It should not corrode metals or stain textile fabrics, nor should it be affected by heat.

Although not in common use, certain derivations of β-naphthol are powerful disinfectants, more particularly those known as the halogen-substituted naphthols. Several β-naphthol disinfectants are now obtainable, "abrastol," for example, which is composed of the calcium or aluminium salts of β-naphthol sulphonate.

Perchloride of mercury ($HgCl_2$) is a very powerful disinfectant. A strength of 1 in 1000 will kill non-sporing bacteria in thirty minutes, and 1 in 500 will destroy spores in one hour. It is exceedingly poisonous, corrodes metals, and forms insoluble compounds with albuminous matter. For the latter reason it should not be used for disinfecting substances containing organic matter, such as fæces, as the insoluble albuminate coat hinders penetration. Furthermore, substances containing sulphides are not satisfactorily disinfected, as the mercury is precipitated as a sulphide, and so rendered inactive. The probable explanation of this is that its power depends upon the presence of the metallic ion, the sulphide of mercury therefore un-ionises the solution.

The L.G.B. recommended the following formula: mercury perchloride 0·5 oz.; HCl 1 oz.; aniline blue 5 grains; and water 3 gallons. This represents a 1 in 960 solution. The object of the acid is to increase the solubility of the salt and, according to some authorities, to lessen the amount of the insoluble albuminate, but the corrosive action on metals is increased thereby. Chlorides in general are said to increase the stability of the solution, but at the same time to reduce its activity. The aniline blue is added to distinguish the solution from ordinary water, but the amount is liable to stain textile fabrics. Three grains would be sufficient. Warmth accelerates the action and increases the potency.

Crude carbolic acid is a mixture of phenol, ortho-, meta-, and para-cresols and inert tar oils. It has a wide range of applicability, as it does not coagulate albumen. It may be used for clothing, bedding, excreta, and sputum, etc., at a strength of 1 in

20, but should not be depended upon for killing spores. This strength does not harm fabrics or affect colours and metals, but it is apt to leave a stain, due to the presence of the tar oils and other impurities. On account of the cresols its carbolic acid coefficient is greater than that of pure phenol. As a rule it falls between 2 and 3. When mixed with water it should be thoroughly agitated, as it dissolves with difficulty. Heat increases its power. Its probable effect on the organism is simply toxic. Pure phenol (C_6H_5OH) is sometimes employed. It is not so efficient as crude carbolic acid, but it has the advantage of leaving no stain. Carbolic acid powders consist mainly of cresylate and carbolate of lime, which are almost inert substances possessing little or no germicidal power. Calvert's carbolic acid powder is probably the best, as it contains no lime. It is manufactured by compounding the acid with a siliceous base.

"Formalin" (CHOH) is a 40% solution of formaldehyde. It is not injurious to most articles, and its action is not seriously affected by organic or albuminous matter. It may be used, therefore, to disinfect urine, excreta, and sputum, but is more commonly applied as a spray or in gaseous form for treatment of rooms, etc. Its carbolic acid coefficient is about 0·5. The strength usually employed in 2·0%. When formalin is heated, para-formaldehyde or paraform results. Paraform is a solid polymer of formaldehyde, and, when heated, dissociates with evolution of formaldehyde. It is a poison, and should not be used hot.

Potassium permanganate ($K_2Mn_2O_8$) is a powerful oxidising agent, as each molecule is capable of parting with 5 atoms of oxygen. Its disinfecting property is due to this fact. For this reason it is not a satisfactory disinfectant for substances containing much organic matter, and, as it stains textile fabrics, its application is limited. The stains, however, can be removed by oxalic acid or lemon juice. A dilution of 1 in 800 was found to kill pus cocci in two hours, and a 1% solution the B. mallei in two minutes. Koch found that 5% destroyed spores in twenty-four hours.

Chlorine gas is occasionally used. It may be prepared in several ways. A simple method is to add sulphuric acid to bleaching-powder or to common salt and manganese dioxide. Moisture very considerably enhances its value as a disinfectant. In the presence of steam, 3 volumes of the gas per thousand volumes of air will disinfect in about eight hours. This amount can be produced by the inter-action of 1·5 lbs. of fresh bleaching-powder and 6 oz. of strong sulphuric acid. It has the disadvantage of bleaching colours, and owing to its weight it needs to be generated in an elevated position in order to facilitate diffusion. It must be noted that the compounds formed between chlorine, or the hypochlorites, and organic matter are in themselves powerful

germicides. According to the investigations of Rideal, these bodies consist of chloro-proteids, chloramines, and hydrazine. The carbolic acid coefficient of chlorine water is 28, or 2·2 for every 1% of available chlorine. If an equivalent of ammonia is added, the coefficient is raised to 6·4 for every 1% of available chlorine. As the germicidal power of ammonia is very small, the increased value is due to the production of chloramine (NH_2Cl). Hydrazine is the result of union of chloramine with more ammonia ($2NH_2HCl$), the coefficient of which is about 20.

Sulphurous acid is also used and, as in the case of chlorine, moisture adds to its power. A very convenient way of generating this gas is by burning roll sulphur, at least 3 lbs. being required for every 1000 cubic feet of air. Cylinders containing the liquified gas are also employed. Owing to its affinity for oxygen it acts as a reducing agent; its disinfecting property in all probability is due to this fact. It is a heavy gas and tarnishes metals.

Lime as CaO, owing to its marked alkalinity, is a good disinfectant. If mixed in mass with excreta, sterilisation will be effected in a matter of four to six hours.

Copper sulphate solution is sometimes employed. Its power depends upon the amount of metal present. The carbolic acid coefficient of copper sulphate is 2·0.

Zinc chloride is now little used, but at one time it was widely employed under the name of "Burnett's fluid." It is a poor disinfectant, with a carbolic acid coefficient of about 0·15.

DISINFECTION

Disinfection in the Sick-room.—Sputum and nasal discharges are best collected in gauze and burned. If the amount is considerable, a sputum flask containing a little plain water or 5% carbolic will be necessary. In individual cases the contents of the flask may be burned in a domestic range or fireplace. In hospitals where much sputum has to be dealt with some form of steam autoclave may be installed for sterilising such discharges. Infective fæces and urine should be received in a bed-pan containing a small quantity of 5% carbolic. As soon as the patient has emptied his bladder or rectum more 5% carbolic should be added, equal in amount to the bulk of the excreta. Lumps of fæces should be broken up with a small piece of stick, which should be left in the pan. The whole should then be left standing for two hours, when it may either be thrown down the drain in a water-carriage system or buried in the ground where conservancy methods are in force. Other plans are to add some hot water to the stool, followed by about one quarter the total bulk of quicklime, or cover with an equal amount of a 5% solution of bleaching-powder. In neither case should such a mixture be discharged down a drain, on account of the risk of blockage. Whatever method is adopted, it is always necessary to break up lumps of fæces and

to allow at least two hours' contact. In fever hospitals typhoid fæces are sometimes dealt with in special steam sterilisers.

If no central disinfecting station exists, all bed linen, blankets, and such like should be soaked in a 3% carbolic acid solution for twelve hours before being washed. Linen soiled with excreta should never be boiled without preliminary soaking, or permanent staining will result. Blankets should never be boiled.

Hand lotions for sick-room attendants may be made of 1 in 1000 perchloride of mercury or some coal tar derivative of equivalent strength, and thermometers should always be kept in a disinfectant solution, such as 5% carbolic acid or 70% alcohol.

Disinfection of Rooms.—Preparation of the room: All articles of little value, such as toys and cheap books, should be burned. Mattresses, bedding and all fabrics should be removed in special bags to the disinfecting station or treated at home, as already suggested. Furniture should be drawn away from walls and drawers emptied and opened. The room will now be ready for treatment.

A. *Gaseous Disinfection.*—All cracks and outlets from the room must be hermetically sealed. This is best done by pasting paper over the fireplace, the window-frame and, after the room is closed, over the margins of the door and the keyhole.

Formaldehyde is perhaps the best gaseous disinfectant to apply. It may be employed either as formalin or as paraform tablets. In the former case Lingner's apparatus may be used. In this there is a ring boiler with a central reservoir containing formalin; the steam generated in the boiler enters the reservoir and drives out the formalin in a fine spray through four small openings. From $\frac{1}{2}$–$\frac{3}{4}$ pint of formalin should be used for every 1000 cubic feet of space. It is recommended that a little glycerine should be mixed with the formalin to prevent polymerisation. Trillat's apparatus consists of an autoclave in which water, calcium chloride, and formalin are heated, and, when the pressure reaches about three atmospheres, the steam and formaldehyde are allowed to escape through a fine pipe. The instrument is usually kept outside the room and the pipe inserted through the keyhole. In the Autan process 10–15 oz. of formalin are poured over 5 oz. of potassium permanganate crystals (in a deep metal dish), when sufficient formaldehyde will be generated to disinfect 1000 cubic feet of room. If paraform tablets are used, twenty-five to thirty per 1000 cubic feet may be heated in a special lamp (Alformant). It is useful to remember that, if 100 of these tablets are dissolved in $\frac{1}{2}$ pint of boiling water, the solution will represent approximately the same bulk of formalin. Whatever method of formaldehyde disinfection is practised, a temperature of 70° F. and a relative humidity of 75% are advisable, and the room should remain closed for at least six hours. Formaldehyde harms practically none of the contents of a room.

Sulphur Fumigation.—If 1 lb. of crushed roll sulphur is burned, about 2 lbs. or 11 cubic feet of SO_2 are evolved. This represents approximately 1% of the gas per 1000 cubic feet of space. At least 3% should be provided for disinfection, hence it is customary to burn 4 lbs. of sulphur for every 1000 cubic feet of room. The sulphur should be placed on a metal shovel or similar surface, and care should be taken to prevent fire. As the gas is heavy it is advisable to generate it at some height from the floor and at more than one point in the room. If quite dry, SO_2 has little disinfectant action, hence the room should be sprinkled with water prior to the process. A little methylated spirit poured over the sulphur makes it easier to set alight. Sulphur candles or cylinders of SO_2 may also be used in place of roll sulphur. If possible the room thus treated should be kept shut for twenty-four hours. Sulphurous acid bleaches a good many colours and acts on metals and all cotton and linen fabrics. Sulphur fumigation is of most use in the destruction of vermin.

B. *Liquid Spraying.*—Formalin, 6 oz. to the gallon of water, may be applied to all surfaces of a room by means of a hand-worked pump, such as the Mackenzie sprayer. A 1% solution of liq. cresol. sap. or other disinfectant of equal strength may be similarly used. It is best, when spraying walls, to begin at the floor level and work upwards. The room should be kept closed for six hours after the operation.

Such methods of room disinfection are of doubtful value unless thorough ventilation and subsequent cleansing are carried out. Free perflation of the room should be allowed for a period of twenty-four hours, and then all surfaces should be well scrubbed with hot water and soap. If possible, wall-papers should be stripped off, and any lime-washed surfaces should be relimed. The addition of 2 oz. of bleaching-powder to the gallon of limewash forms a very useful mixture. In small tenement dwellings, where families occupy perhaps only two rooms, the problem is specially difficult, but if formalin spraying is begun in the morning, it should be possible to have the whole cleansing finished by night. In some cases a family may have to be accommodated in a special reception house while disinfection of the home is carried out.

Disinfection of Fomites.—Where no central disinfecting station exists, clothing should be dealt with, as already suggested, by steeping in a disinfectant solution and thorough washing. All other articles which cannot be soaked in disinfectant or destroyed should be left in the room during disinfection and subsequently exposed to the air and sun for a whole day.

If the Local Authority undertakes disinfection, all bedding and clothing should be placed in a bag, marked with the name and address of the householder, and taken to the disinfecting station in a special van. A careful list of everything removed should be

made. Steam disinfection is the most useful method to adopt, except in the case of blankets, boots, furs, books and similar articles. Linen, etc., soiled with discharges should never be treated directly with steam, otherwise the stains will remain permanently fixed in the fabric. Steam disinfection may be carried out either by steam under pressure or by current steam. Superheated steam should not be used in ordinary disinfection processes. The Washington-Lyon machine (Manlove, Alliot & Co.) is a good illustration of the high-pressure method. It consists of a hollow jacketed metal chamber with a separate boiler. The articles to be disinfected are placed in a large wire cradle which can be run out of the chamber on rails, like a small truck. Hooks are also provided on which smaller things may be hung. At each end is a heavy door fastening by clamps, the infected goods being always loaded at one end and the disinfected removed through the other. When the chamber is filled and the doors closed, steam at a temperature of 240–250° F., *i. e.* at about 15 lbs. pressure, is admitted to the hollow jacket, in order to heat the inner surface of the chamber and so prevent condensation of the steam. When the walls have been sufficiently heated, a partial vacuum is produced inside the chamber by blowing a steam jet over a small orifice leading into the chamber. This aids penetration of the steam. The next step is to discharge steam under pressure into the disinfector. This is continued for a period of fifteen to twenty minutes, when disinfection will be complete. It will be remembered that the steam generated from water under pressure will condense practically at its own temperature, hence more steam will be drawn into the partial vacuum thus formed, until penetration of the whole of the contained articles will be secured. Clothing will be somewhat damp after such treatment, so before removing articles from the chamber a partial vacuum is again produced by the special arrangement provided, and a current of hot air drawn through the disinfector. This hot air is obtained by passing air through a pipe surrounded by the boiling water. The whole process from the commencement of loading to the final unloading occupies half an hour. In other disinfectors the lower part of the jacket is made to form the boiler. In some a special recording apparatus is supplied which shows exactly the temperatures reached during the process. In current steam disinfectors the lower part of the jacket forms the boiler, and in some cases, *e. g.* the Thresh, a solution of calcium chloride is used in the boiler as it boils at a higher temperature than 212° F. Somewhat longer contact should be given in such machines. An intelligent man should be employed on this work and the same man should always be in charge, for the best results can only be obtained by careful loading and attention to many details. The efficiency of any machine may be tested by placing in the centre of articles to be disinfected sterilised pieces of gauze or lint smeared

with cultures of various organisms. After exposure to the steam for the usual period, the strips should show no growth when placed in broth. Maximum thermometers may be set in different parts of the chamber, or special electrical arrangements may be obtained which make contact only when a given temperature is reached and so ring a bell outside the machine.

Articles liable to be damaged by steam may be treated at the station by means of formalin, and various patterns of steam disinfectors may be fitted with a small apparatus whereby formaldehyde may be passed into the chamber. In this case the temperature of the chamber is first raised by blowing steam into the jacket, a partial vacuum is next produced, and finally formaldehyde and hot air are admitted for the requisite time. In this way leather goods, furs and books may be disinfected.

The Disinfecting Station.—The most important point is that there should be a " dirty " end and a " clean " end, with no intercommunication save through the disinfecting machine. The machine should be built into the dividing wall between the two compartments, and a small panel of glass should be provided in the same wall for observation purposes. Infected articles are brought to the station in an " infected van " and taken back to the various owners in a " clean van." It is just as well to have these two vans painted different colours, and a separate garage or stable must be arranged for each. The structure of the buildings should be such that they can be readily cleansed in every part. Store-rooms for infected and disinfected articles are advisable, and a laundry is sometimes supplied. Nowadays baths are usually attached, where verminous persons, especially school children, may be cleansed while their clothing is being disinfested.

Reception houses are frequently associated with disinfecting stations. They are used for the housing of contacts of such diseases as smallpox, typhus, plague or cholera. No attempt need be made to secure complete quarantine of such persons, but their removal to a well-regulated establishment affords opportunity for proper cleansing and skilled observation. Sometimes it is possible to convert an old house into suitable quarters; at all events the site must be fairly central, so that workpeople detained in the building may not be at too great a distance from their work. Quarters for more than one family, or more than one disease, should be provided. A caretaker will be required, and a nurse or health visitor should be in attendance when the reception house is occupied.

SECTION VIII

VITAL STATISTICS

STATISTICS from the Public Health student's point of view consist of—

(a) The estimation of the population.
(b) The calculation of rates.
(c) The compilation of tables.
(d) The determination of errors.

The **population** can be estimated in four ways—

(a) By the census.
(b) By the inhabited-house method.
(c) By a formula.
(d) By the Registrar-General's method.

(a) The census is the most accurate, as the people are actually enumerated. Other facts can be determined at the same time, such as the number of males and females, the number living at any age, the number following any occupation. This information can be obtained only by this method. It is taken once every ten years. This infrequency is unsatisfactory, as a true conception of the death-rates, which are calculated upon the entire population, can be arrived at once only in ten years. Also, it is taken at the end of the first quarter of the year. This, again, is unsatisfactory. Populations as a rule increase, therefore it is obvious that a population calculated up to the end of the second quarter of the year is the mean population for that year. Mid-year populations should always be obtained.

(b) The population by this method is the product of the number of inhabited houses in the community, and the average number of persons occupying each inhabited house as calculated from the rate-books. To make the estimation more complete, it is usual to add one person for every uninhabited house. In this way caretakers occupying so-called unoccupied houses are included.

$$(c)\ \text{Population} = \frac{\text{No. of births registered in the year} \times 1000}{\text{Birth-rate}}.$$

This method gives fairly accurate results if the birth-rate is

stationary, but migration and a fluctuating birth-rate lead to an inaccurate estimation.

(*d*) The Registrar-General's method. This involves the use of logarithms.

Example.—The population of a town in 1901 was 45,600, and in 1911 it had increased to 50,100. Calculate the population for 1917.

First, find the logarithms of the two populations.

$$\begin{aligned} \text{Logarithm of } 50{,}100 &= 4{\cdot}6998377 \\ \text{,, \quad ,, } 45{,}600 &= 4{\cdot}6589648 \\ \hline \text{Difference} &= 0{\cdot}0408729 \end{aligned}$$

This is the logarithm of ten years' increase of population.

$\therefore$ 0·0408729 $\div$ 10 = 0·00408729. This is the logarithm of one year's increase of population. From the census of 1911 to the middle of the year 1917 is an increase of 6·25 years.

$\therefore$ 0·0040873 (nearly) $\times$ 6·25 = 0·025545625 = the logarithm of 6·25 years' increase of population.

$\therefore$ 4·6998377 + 0·025546525 = 4·7253833 = the logarithm of the population in 1917.

$\therefore$ Population = 53,135.

This method is open to the objection that the same rate of increase between two census years will be maintained for all subsequent years. It frequently gives unsatisfactory results, more particularly if applied to a small community than to the country as a whole. The magnitude of the error when large populations are under consideration is so small that it may be almost disregarded.

Populations increase upon a geometrical basis. It is obvious that the bigger the population, the bigger the increase. If x population becomes $2x$ in y years, then x population becomes $4x$ in $2y$ years, and x population becomes $8x$ in $3y$ years, since x becomes $x + x$ in y years, $x + x$ must become $x + x + x + x$ in another y years.

Logarithms take this geometrical increase into account. A logarithm is an index of the power to which a base is raised to give a certain number. If, for example, 10 is the base and 1000 is the number, then 3 is the logarithm, as 3 indicates the power to which 10 must be raised to equal 1000.

Similarly—

10^5 =	100,000	log.	= 5
10^4 =	10,000	,,	= 4
10^3 =	1,000	,,	= 3
10^2 =	100	,,	= 2
10^1 =	10	,,	= 1
10^0 =	1	,,	= 0
10^{-1} =	0·1	,,	= − 1

From this it will be seen that the addition of two logarithms is the multiplication of their numbers, as log. 3 + log. 2 = log. 5, their respective numbers being 1000, 100 and 100,000.

The subtraction of one logarithm from another is the division of their

numbers, as log. 3 − log. 2 = log. 1, their respective numbers being 1000, 100 and 10.

or $\quad$ log. of x + log. of $y = x \times y$

and $\quad$ log. of x − log. of $y = x \div y$

or $\quad$ log. of $x + 1, + 1, + 1$
$= x \times 10 \times 10 \times 10$

and $\quad$ log. of $x - 1, \ - 1, \ - 1$
$= x \div 10 \div 10 \div 10.$

It is obvious that any number between 1000 and 10,000 must have a logarithm between 3 and 4.

The log. of 4421 is 3·6455205.

$$\therefore\ 3{\cdot}6455205 + 1 \ + 1 \ + 1 = 4421 \times 10 \times 10 \times 10$$

or

$$\text{log. } 3{\cdot}6455205 = 4421$$
$$\text{,, } 4{\cdot}6455205 = 44210$$
$$\text{,, } 5{\cdot}6455205 = 442100$$
$$\text{,, } 6{\cdot}6455205 = 4421000.$$

∴ Any number multiplied or divided by 10, or a multiple of 10, has the whole number (the characteristic) only of its logarithm altered; the decimal places (the mantissa) remain the same.

The n^{th} power of a number is its logarithm multiplied by n, as $315^5 = (\text{log. of } 315) \times 5$.

The n^{th} root of a number is its logarithm divided by n, as—

$$\sqrt[5]{315} = (\text{log. of } 315) \div 5.$$

Example.—The population of a town in 1901 was 45,600, and in 1911 it had increased to 50,100. Find the population for 1917. It is obvious that the average annual increase from 1911 to 1917 will be greater than the average annual increase from 1901 to 1911. Hence if this arithmetical rate of increase be assumed to occur for future years, an under-estimation of the population must inevitably result.

Let $\quad$ P = population
$\quad r$ = annual increase per unit of population.

Then 1 person becomes $1 + r$ in one year, and P persons become $P(1 + r)$.

As there are now $P(1 + r)$ persons to increase upon, there will be—

$P(1 + r)\,(1 + r)$ persons in 2 years, or $P(1 + r)^2$

or $\quad P(1 + r)^{10}$ in ten years,

that is, P has become $P(1 + r)^{10}$ in ten years.

In the example 45,600 became 50,100.

$$\therefore\ P = 45{,}600, \text{ and } P(1 + r)^{10} = 50{,}100$$

or

$$P = 45{,}600, \text{ and } 45{,}600 \times (1 + r)^{10} = 50{,}100.$$

As $50{,}100 = 45{,}600 \times (1 + r)^{10}$, then log. of 50,100 = log. of 45,600 + (10 × log. of $(1 + r)$), ∴ log. of 50,100 − log. of 45,600 = 10 × log. of $(1 + r) = \dfrac{\text{log. of } 50{,}100 - \text{log. of } 45{,}600}{10}$ = log. of $(1 + r)$.

$$\text{log. of } 50{,}100 = 4{\cdot}6998377$$
$$\text{log. of } 45{,}600 = 4{\cdot}6589648$$
$$\therefore \quad \frac{4{\cdot}6998377 - 4{\cdot}6589648}{10} = \text{log. of } (1 + r)$$

or

$$0{\cdot}00408729 = \text{log. of } (1 + r).$$

The number corresponding to log. 0·00408729 is 1·01, ∴ $1{\cdot}01 = (1 + r)$.

As we have seen that 1 person becomes $(1 + r)$, then 1 person becomes 1·01 in one year.

∴ the population in 1917 must be the population in 1911 multiplied

by the $(1{\cdot}01)^{6\cdot25}$. It must be remembered that as the census is calculated up to the end of the first quarter of the year, there must be 6·25 years increase of the population up to the middle of 1917.

$\therefore$ population for 1917 $= 50{,}100 \times (1{\cdot}01)^{6\cdot25}$

or log. of 50,100 + (6·25 × log. of 1·01)

or 4·6998377 + (6·25 × 0·0040873)

or 4·7253833.

The number of log. 4·7253833 is 53,135.

$\therefore$ the population in 1917 is 53,135.

Let it be required to find the number of years the population in the example given will take to double itself, or in what year will 45,600 become 91,200 persons, on the assumption that the increase will be at the same rate?

i. e. $91{,}200 = 45{,}600 \times (1 + r)^n$

or $91{,}200 = 45{,}600 \times (1{\cdot}01)^n$

$\therefore$ log. of 91,200 = log. of 45,600 + (n(log. of 1·01))

or log. of 91,200 = log. of 45,600 + (n × 0·0040873)

log. of 91200 = 4·9599948

log. of 45,600 = 4·6589648

$\therefore$ 4·9599948 − 4·6589648 = n × 0·0040873

or 0·30103 = n × 0·0040873

$$\therefore \frac{0{\cdot}30103}{0{\cdot}0040873} = n$$

$\therefore$ n = 73 (nearly).

In seventy-three years from 1901, or in 1974, the population will have doubled itself.

Death-rates.—A *crude death-rate* is the number of deaths in a year per thousand of the population;

$$\text{or} \quad \frac{\text{No. of deaths registered in the year} \times 1000}{\text{population}}.$$

Hence a Quarterly Death-rate—

$$= \frac{\text{No. of deaths in 13 weeks} \times 4 \times 1000}{\text{population}}.$$

A Monthly Death-rate—

$$= \frac{\text{No. of deaths in 4 weeks} \times 13 \times 1000}{\text{population}}.$$

A Weekly Death-rate—

$$= \frac{\text{No. of deaths in 1 week} \times 52 \times 1000}{\text{population}}.$$

(The exact number of weeks in the year is 52·17747.)

It is needless to say that any rate, calculated upon a period of time less than a year, is apt to overstate or understate the true rate. For it does not follow that the number of deaths for the whole year will be four times the number occurring in any quarter, or thirteen times the monthly number, or fifty-two times the weekly number.

For example: What is the death-rate of enterica for a

community of 500 persons, in which two persons died from typhoid fever in the last quarter of the year?

Applying the formula, we get—

$$\frac{2 \times 4 \times 1000}{500} = 16.$$

The inference to be drawn from this is not that sixteen deaths occurred, but that this population would have furnished sixteen deaths from typhoid fever in the year if they had continued to die throughout the entire year at the same rate as they did in that particular quarter. It is simply a rate. As has been shown, owing to seasonal influence, the highest rate of mortality for typhoid fever is in the last quarter of the year. The fallacy of the above rate of 16 per 1000 is obvious, as it assumes that the highest rate of mortality will be maintained.

Hospitals and similar institutions attract people who are ill, and therefore many deaths occur in these places which ought to be assigned to other districts than those in which the hospitals are situated. In the yearly returns allowance should be made for this fact by excluding the deaths of non-parishioners, but, of course, including those parishioners who died without the area under consideration. In this way a number of deaths is obtained which, when multiplied by 1000, and divided by the population, gives a *Recorded Death-rate.*

From the following tables it will be seen that the highest mortality occurs at the two extremes of life, and that as a whole females have the lower death-rates; also that urban areas, being for the most part industrial centres, have a bigger proportion of people living in the middle-age periods of life, ages at which the death-rates are low; and that rural areas show an increase in the number of old people.

THE AGE AND SEX DISTRIBUTION OF ONE MILLION PERSONS OF ENGLAND AND WALES FOR THE YEAR 1901

Age periods.	Males.	Females.	Total.	Urban.	Rural.
0–5	57,039	57,233	114,262	114,348	113,978
5–10	53,462	53,747	107,209	105,555	112,760
10–15	51,370	51,365	102,735	101,147	108,397
15–20	49,420	50,376	99,796	101,080	95,489
20–25	45,273	50,673	95,946	100,291	81,370
25–35	76,425	85,154	161,579	167,597	141,390
35–45	59,394	63,455	122,849	124,282	118,039
45–55	42,924	46,298	89,222	88,368	92,086
55–65	27,913	31,828	59,741	56,642	70,139
65–75	14,691	18,389	33,080	29,502	45,080
75–85	5,080	7,010	12,090	10,102	18,758
Over 85	552	939	1,491	1,186	2,514
All ages	483,543	516,457	1,000,000	1,000,000	1,000,000

DEATH-RATES OF ENGLAND AND WALES FOR THE YEAR 1913

Age periods.	Males.	Females.
All ages	14·8 per 1000	12·0 per 1000
0–5	39·2 ,,	32·2 ,,
5–10	3·1 ,,	3·1 ,,
10–15	1·9 ,,	2·0 ,,
15–20	2·7 ,,	2·5 ,,
20–25	3·5 ,,	3·0 ,,
25–35	4·6 ,,	3·8 ,,
35–45	8·0 ,,	6·5 ,,
45–55	15·0 ,,	11·5 ,,
55–65	30·7 ,,	23·0 ,,
65–75	64·5 ,,	51·1 ,,
75–85	140·4 ,,	117·5 ,,
Over 85	266·8 ,,	241·0 ,,

From this it must follow that, unless some correction is made for these irregularities of distribution as regards age and sex, no just comparison can be drawn between the Recorded Death-rates of two districts with the view of determining their relative healthiness. Hence it becomes necessary to calculate a "*Corrected Death-rate.*"

In order to do this we must obtain—

1. A Standard Death-rate;
2. A Factor for Correction; and then—
3. Factor × Recorded Death-rate = Corrected Death-rate.

Firstly, the population of the district is divided into age groups for the two sexes separately. Then by applying the death-rates of England and Wales for each sex at each age group to the populations in the corresponding age and sex groups, a calculated number of deaths is found. In other words, the populations at the various ages are assumed to die at the same rate as that which prevails in the whole of England and Wales.

$$\frac{\text{Calculated No. of deaths} \times 1000}{\text{District population}} = \text{the Standard Death-rate.}$$

Then—

$$\frac{\text{Death-rate of England and Wales}}{\text{Standard Death-rate}} = \text{the Factor for Correction.}$$

To make this quite clear, let us take the example of Huddersfield (Newsholme's *Vital Statistics*)—

Ages.	Population of Huddersfield in 1891.		Mean Annual D.R. in E. and W. 1881–90 per 1000 living at each group of ages.		Calculated number of deaths in Huddersfield.	
	Males.	Females.	Males.	Females.	Males.	Females.
0–5	4,551	4,785	61·59	51·95	280	249
5–10	4,691	5,081	5·35	5·27	25	27
10–15	5,113	5,165	2·96	3·11	15	16
15–20	4,905	5,549	4·33	4·42	21	25
20–25	4,541	5,461	5·73	5·54	26	30
25–35	7,466	8,834	7·78	7·41	58	65
35–45	5,576	6,265	12·41	10·61	69	66
45–55	3,944	4,649	19·36	15·09	76	70
55–65	2,393	3,017	34·69	28·45	83	86
65–75	1,128	1,590	70·39	60·36	79	96
75 & upwards	250	466	162·62	147·98	41	69
	44,558	50,862			773	799
Totals .	95,420				1,572	

From this table we see that the male population under five years in Huddersfield for 1891 was 4551, and that the death-rate for males under five years for England and Wales was 61·59 per 1000.

By applying this rate of dying to 4551, we obtain 280—

$$i.e. \qquad \frac{61{\cdot}59 \times 4551}{1000} = 280$$

$$\text{and} \qquad \frac{51{\cdot}95 \times 4785}{1000} = 249.$$

In this way the last two columns are filled in.

$$\therefore \quad \frac{1572 \times 1000}{95420} = \text{Standard Death-rate for Huddersfield} = 16{\cdot}47.$$

$$\therefore \quad \frac{19{\cdot}15 \text{ (Death-rate for England and Wales)}}{16{\cdot}47} = \text{Factor for Correction} = 1{\cdot}1627.$$

Recorded Death-rate of Huddersfield × 1·1627 = the Corrected Death-rate.

The rationale of this is as follows. If the age and sex con stitution of the population of Huddersfield was the same as that of England and Wales, then obviously the Standard Death-rate and the death-rate of England and Wales would be precisely the same. The more closely the two death-rates are in agreement, the closer the two population distributions approximate. In fact, the ratio of the two rates is identical with the ratio of

the two distributions. The population of Huddersfield, therefore, was so constituted that it was under-estimating the death-rate, and that the true rate ought to be raised in the proportion of 16·47 to 19·15.

Another method of calculating the Corrected Death-rate is the "Standard Million." In this method the death-rates of the community are applied to the respective age-group populations of a million persons, the constitution of which with regard to age and sex is exactly the same as for England and Wales.

The mean population of England and Wales in 1881–1890, reduced to a million persons, was constituted as follows—

Ages.	Males.	Females.	1 Males.	2 Females.	3 Males.	4 Females.
0–5	64,122	64,557	62·0	52·0	3976	3357
5–10	59,333	59,673	5·4	5·1	320	304
10–15	54,806	54,765	3·0	3·1	164	170
15–20	49,720	50,287	4·5	4·8	224	241
20–25	42,922	47,564	5·5	5·2	236	247
25–35	71,131	77,499	7·8	7·5	555	581
35–45	55,095	58,944	12·5	11·0	689	648
45–55	40,472	44,478	18·4	15·0	745	667
55–65	27,151	30,893	34·5	28·5	937	890
65–75	15,184	18,326	70·0	61·3	1063	1123
75 & upwards	5,591	7,487	165·0	149·0	923	1116
All ages	485,527	514,473			9832	9344
	1,000,000				19,176	

Columns 1 and 2 are the annual death-rates per thousand living at each group of ages for the community. Columns 3 and 4 are the numbers of deaths which would have occurred in the male and female populations of the Standard Million if they had died at the rates in columns 1 and 2.

e.g. $$\frac{62 \times 64{,}122}{1000} = 3976$$

$$\frac{52 \times 64{,}557}{1000} = 3357$$

In that way it is calculated that 19,176 deaths occurred out of the million.

$$\therefore \frac{19{,}176 \times 1000}{1{,}000{,}000} = 19{\cdot}176, \text{ the Corrected Death-rate for the Community.}$$

Comparative Mortality Figure

$$= \frac{\text{Corrected Death-rate} \times 1000}{\text{Death-rate of England and Wales}}\cdot$$

Combined Death-rate.—A town with a population of 56,000 has a death-rate of 18 per 1000; an adjacent town has a population of 11,000, and a death-rate of 10 per 1000. What is the death-rate for the combined areas?

It is not the mean of the two rates 18 and 10, namely 14, as the populations are not the same;

but—
$$\frac{\left(\frac{56,000 \times 18}{1000} + \frac{11,000 \times 10}{1000}\right) \times 1000}{56,000 + 11,000}.$$

That is, it is the sum of the total deaths in each town, which is then expressed as a rate per thousand of the combined population.

$$= \frac{(1008 + 110) \times 1000}{67,000} = 16{\cdot}6.$$

Zymotic Death-rate

$$= \frac{\text{No. of deaths from the zymotic diseases} \times 1000}{\text{population}}.$$

The seven principal zymotic diseases are: Small-pox, Measles, Scarlet Fever, Diphtheria, Whooping-cough, Diarrhœa and Fever (Typhoid, Typhus and Simple Continued).

All death-rates are calculated upon the entire population, unless the disease of which the death-rate is being sought has a special age or sex incidence.

Puerperal Fever Death-rate

$$= \frac{\text{Number of deaths from puerperal fever} \times 1000}{\text{Number of registered births}}.$$

Here the number of births indicates the number of women liable to die from the disease. Still-births, abortions, twins, etc., interfere with the accuracy of the result, inasmuch as the first two are not registered at all, and the last counts as two births.

The *cancer death-rate* is usually expressed as the number of deaths from cancer per thousand of the population. Again, owing to the fact that the bigger proportion of cancer deaths occurs over the age of thirty-five years, it would be more exact to state the rate as deaths per thousand of the population living over that age. This would enable a statement to be made with more definiteness and accuracy as to whether cancer was really on the increase, and as to its relative prevalence in different localities. The rate for males for the year 1915 was high. This was to be expected, owing to the large number of men living below the cancer age, so to speak, who were in the Army and serving abroad, thus relatively increasing the number of

lives at risk at home, as service men were not included in the civil population.

Diarrhœa and enteritis are diseases which attack mainly children under two years of age. In consequence of this a complete misconception of the gravity of a situation might easily arise. If a town has a low birth-rate, which implies that there is an increased proportion of people living beyond the age of infancy, it necessarily follows that, in spite of a heavy toll of these diseases among the few children there are, the death-rate based upon the population would be low.

$$\textbf{Marriage rate} = \frac{\text{No. of marriages} \times 1000}{\text{population}}.$$

Here again it would be better if the denominator were the number living at marriageable ages.

$$\textbf{Birth-rate} = \frac{\text{No. of births in the year} \times 1000}{\text{population}}.$$

This may give a false idea of fertility. The number of children born depends upon the number of women married. Therefore the Corrected Birth-rate or Fertility Rate

$$= \frac{\text{No. of legitimate births} \times 1000}{\text{No. of married women between 15–45 years}}.$$

As this does not include the illegitimate births, a separate birth-rate is calculated.

Thus **Illegitimate Birth-rate**

$$= \frac{\text{No. of illegitimate births} \times 1000}{\text{No. of unmarried women and widows between 15–45 years}}.$$

The following table shows how necessary it is to consider only the married women, and not the women as a whole, when calculating the legitimate birth-rate. As there are many more unmarried women (domestic servants) in Kensington than in Whitechapel, it will be observed that the rates of the two localities, based upon the unmarried women population, are widely divergent, but they more closely approximate when only the married women are taken into account.

	B. R. per 1000 of population.	B. R. per 1000 women aged 15–45.	B. R. per 1000 married women 15–45.
Kensington . .	21·8	61·6	215·4
Whitechapel . .	39·9	172·1	328·3
Percentage excess of birth-rate in Whitechapel over that in Kensington.	83	179	53

Infantile Mortality Rate [1]

$$= \frac{\text{No. of deaths under 1 year of age} \times 1000}{\text{No. of registered births in the year}}.$$

Density.—The density of the population is expressed as the number of persons per acre or square mile, or the number of acres per person. Where the population is dense, the mortality is almost invariably high. Close aggregation usually means filthy conditions, with the consequent contamination of water, food, air, and soil. A congested area is, as a rule, a poor one, with the inevitable concomitants of poverty, phthisis, high prevalence of infectious diseases, with facilities for their dissemination, inferior sanitation, intemperance, and greater liability to accidents.

Dr. Farr found that the mortality increased with the eighth root of the densities.

Thus— $$\frac{m^1}{m} = \sqrt[8]{\frac{d^1}{d}}$$

or— $$m^1 = m\left(\frac{d^1}{d}\right)^{0.12}$$

m^1 and m = the mortality rates of two places,
d^1 and d = the densities of the populations.

This may lead to erroneous results, as it does not take into account the difference between the real and apparent density. If, for example, there was only one two-roomed house, occupied by twenty persons, on one acre of ground, the twenty persons per acre would represent a sparsely inhabited area, and yet really the people would be living in a state of overcrowding, and therefore be far worse off than others more closely aggregated, but housed in well-appointed model dwellings. A truer idea of overcrowding is obtained from the number of persons living in one room.

Occupational Mortality.—The mean age at death, the ordinary death-rate, and the occupational mortality figure are used in order to compare the relative healthiness of various trades and professions. The Mean Age at Death, which is the sum of the ages of the persons who have died divided by the number of deaths, is no criterion of healthiness, as it necessarily depends upon the ages of those who have died. The mean age at death is much lower for cadets than for admirals, and lower for curates than for bishops. This would be expected, as the average age of the cadet or curate is less than the average age of the admiral or bishop. The death-rate is also almost valueless unless the workers compared are in the same age group. It is obvious that the death-rate for judges is higher than the death-rate for solicitors. The best evidence is undoubtedly the Occupational

[1] For notes on Infantile Mortality, *vide* p. 125.

Mortality Figure. But this will not eliminate the error that some trades demand the stronger type of individual. A weak man would not become a blacksmith, he would choose some occupation which required less physical energy, and one which made less demands upon his limited store of endurance.

To calculate the figure of occupational mortality a standard population is required, consisting of those males living between the ages of twenty-five years and sixty-five years, which in the course of one year will furnish thousand deaths. This number is 61,215.

Then it is required to find the number living in each of the four decennia, 25–35, 35–45, 45–55, and 55–65.

Having calculated these, the death-rate for medical practitioners (or whatever trade or profession is to be compared) for each of the four decennia is applied to the corresponding age-group population of the males as a whole. The sum of the deaths thus calculated is the number which would have occurred in the 61,215 if they had been medical practitioners.

For example—

	Standard population.	D. R. per 1000.		Calculated deaths in standard population among	
		All males.	Med. pract.	All males.	Med. pract.
25–35	22,586	7·67	6·69	173	151
35–45	17,418	13·01	14·92	227	260
45–55	12,885	21·37	21·04	275	271
55–65	8,326	39·01	34·16	325	284
	61,215			1,000	966

In this table it will be seen that column 1 contains the 61,215 males divided up into the four decennia; column 2 the death-rate per thousand for all males; column 4 the deaths which would have occurred in column 1 on applying the rates in column 2. Thus—

$$\frac{7{\cdot}67 \times 22{,}586}{1000} = 173$$

$$\frac{13{\cdot}01 \times 17{,}418}{1000} = 227$$

$$\frac{21{\cdot}37 \times 12{,}885}{1000} = 275$$

$$\frac{39{\cdot}01 \times 8326}{1000} = \frac{325}{1000}.$$

Column 3 contains the death-rate per thousand for medical practitioners; column 5 the deaths which would have occurred in column 1 on applying the rates in column 3.

Thus $\frac{6{\cdot}69 \times 22{,}586}{1000} = 151$, and so on.

From this we learn that where 61,215 males produce thousand deaths, if they had been medical practitioners they would have furnished only 966 deaths.

OCCUPATIONAL MORTALITY TABLE

All males	1000
Occupied males	953
Unoccupied males	2215
Clergy	533
Gardeners	553
Teachers	604
Lace workers	709
Tanners	756
Artists	778
Lawyers	821
Blacksmiths	914
Shoemakers	920
Commercial travellers	961
Medical men	966
Shopkeepers generally	973
Hairdressers	1099
Musicians	1214
General labourers	1221
Iron and steel manufacturers	1301
Chimney-sweeps	1311

Case Mortality or Fatality Rate is the percentage number of deaths among those attacked by any given disease. It is the only rate not calculated per thousand. The severity of an epidemic can be measured in that way.

Example.—In a population of 50,000 there were 200 cases of typhoid fever, of whom 30 died.

$$\text{Death-rate} = \frac{30 \times 1000}{50{,}000} = 0{\cdot}6 \text{ per } 1000.$$

$$\text{Case Mortality} = \frac{30 \times 100}{200} = 15\%.$$

The Morbidity Rate is the number of persons suffering from any disease multiplied by 1000, and divided by the population. In the above example, $\frac{200 \times 1000}{50{,}000} = 4$, is the Morbidity Rate of typhoid fever.

Effective population refers to the number of people living between the ages of twenty years and seventy years. **Increment** and **decrement of life** are two terms used to denote the excess of births over deaths and deaths over births respectively.

LIFE TABLES

These are constructed chiefly for actuarial purposes, in order to calculate the Mean Duration of Life or Expectation of Life at Birth, the Expectation of Life at any age or the Mean after Lifetime, and the Probable Duration of Life. As a rule there is a separate table for each sex, which may be constructed for the whole country, or for any special community, or for one million persons supposed to be born at the same time and their lives traced through to extinction. The data required are the numbers living and dying at each and every year of life. To eliminate any error which might arise by taking the returns of any particular year, the averages of the numbers living and dying are taken for a series of years.

The following table from Notter and Firth represents the columns of a life table. It will be noted that only certain ages are dealt with, *e. g.* the age 10 refers to that year only, and not to the quinquennium 5–10.

Age period.	M*x*.	P*x*.	L*x*.	Q*x*.	E*x*.
0	183·26	0·83212	511,745	20,426,138	39·41
5	13·69	0·98640	370,358	18,410,252	49·71
10	5·63	0·99438	353,031	16,608,936	47·01
15	5·19	0·99482	344,290	14,866,429	43·18
20	8·32	0·99171	333,608	13,169,656	39·48
25	9·2	0·99084	319,442	11,536,677	36·12
35	11·05	0·98901	288,850	8,492,601	29·40
45	15·54	0·98458	253,708	5,774,489	22·76
55	24·85	0·97644	209,539	3,447,708	16·45
65	46·98	0·95410	150,754	1,631,508	10·82
75	103·91	0·90122	75,777	491,685	6·49
85	219·66	0·80208	16,877	63,030	3·73
95	420·35	0·65265	833	1,806	2·17

The columns in a simple life table are M*x*, P*x*, L*x*, Q*x* and E*x*.

M*x* = the mortality rate per thousand at year x.
P*x* = the probability of surviving year x.
L*x* = the number living at year x.
Q*x* = the quantity of years lived at year x.
E*x* = the expectation of life at year x.

Example—

Ages.	Population.	Deaths.	M*x*.
1	20,000	2000	100
1–2	15,000	300	20
2–3	14,500	174	12
3–4			
etc.			

$$\therefore\ M_1 = \frac{2000 \times 1000}{20,000} = 100$$

and $$M_2 = \frac{300 \times 1000}{15,000} = 20$$

and $$M_3 = \frac{174 \times 1000}{14,500} = 12.$$

In this way Mx column is filled in.

Px.—If no persons died in any year, then the probability of surviving that year is a certainty. If the theory of probability is not accepted, then inference from experience or experiment becomes an impossibility. The fraction which represents the probability of surviving must always be less than 1, by the fraction which equals the chance of dying. Therefore a certainty of either living or dying always equal unity. In the example the mortality rate between one and two years is 20 per 1000. This, of course, means that in that year twenty will die out of 1000, or that 980 will survive. If this were true, then the probability of surviving that year would be $\frac{980}{1000}$, or—

$$\frac{\text{The number living at the end of the year}}{\text{The number living at the beginning of the same year}}.$$

This assumes that the thousand were living in January, but as we have already seen that populations are calculated up to the middle of the year, the thousand must be taken as living in July. On the assumption that the twenty deaths occurred uniformly throughout the year, there must have been 1010 living in January and 990 in December, and so the true probability of surviving that year is $\frac{990}{1010}$.

Now $$\frac{990}{1010} = \frac{1000 - \frac{1}{2}\text{ deaths occurring in the year}}{1000 + \frac{1}{2}\text{ deaths occurring in the year}}.$$

$$\therefore\ Px = \frac{1000 - \frac{1}{2}\text{ deaths in year x}}{1000 + \frac{1}{2}\text{ deaths in year x}}.$$

Thus—

Age.	Mx.	Px.
–1	100	
1–2	20	$\left(\frac{1000 - \frac{1}{2}\,20}{1000 + \frac{1}{2}\,20}\right) = \frac{990}{1010}$
2–3	12	$\left(\frac{1000 - \frac{1}{2}\,12}{1000 + \frac{1}{2}\,12}\right) = \frac{994}{1006}$

In this way column Px is calculated. P for the first year

life is not calculated by this method, because the numbers living and dying are actually known, but for all subsequent years they are only an estimation. If the population had been classified as quinquennia, and not in one-yearly age-groups, then—

$$Px = \left(\frac{1000 - \frac{1}{2}\,D}{1000 + \frac{1}{2}\,D}\right)^5.$$

Lx.—If there are 1,000,000 at birth, then we have to find what number will be alive at the commencement of the second year of life, and what number will start the third year of life, and so on. Since the mortality rate for the first year of life is 100 per 1000, it is obvious that 100,000 would have died out of the 1,000,000, or that 900,000 would survive.

Now $$P_2 = \frac{990}{1010}$$

$\therefore\ 900{,}000 \times \dfrac{990}{1010} = 882{,}178 =$ survivors at the end of the second year of life.

And $$P_3 = \frac{994}{1006}$$

$\therefore\ 882{,}178 \times \dfrac{994}{1006} = 871{,}655 =$ survivors at the end of the third year of life.

Hence—

$$\begin{aligned} L_1 \times P_2 &= L_2 \\ L_2 \times P_3 &= L_3 \\ L_3 \times P_4 &= L_4 \\ L_4 \times P_5 &= L_5 \quad \text{and so on.} \end{aligned}$$

In that way column Lx is filled in.

The table now appears as follows—

Ages.	Mx.	Px.	Lx.
0	—	—	1,000,000
-1	100	—	900,000
1–2	20	$\frac{990}{1010}$	882,178
2–3	12	$\frac{994}{1006}$	871,655

$$\begin{aligned} Qx &= 900{,}000 + 882{,}178 + 871{,}655 + \ldots\ldots \\ &\quad \text{or } L_1 + L_2 + L_3 + L_4 \ldots\ldots \\ &\quad \text{or } \Sigma Lx\ (\Sigma = \text{the sum of}) \end{aligned}$$

$=$ the total number of years lived by the 1,000,000, or Q_0.

The total years lived by the 900,000

$$\begin{aligned} &= 882{,}178 + 871{,}655 + \ldots\ldots \\ &\quad \text{or } L_2 + L_3 + L_4 \ldots\ldots \end{aligned}$$

But $L_2 + L_3 + L_4 \ldots\ldots = \Sigma Lx - L_1$.

$\therefore \Sigma Lx - L_1$ = number of years lived by the 900,000, or Q_1.

$$\begin{array}{ll} \text{or} & Q_0 - L_1 = Q_1 \\ \therefore & Q_1 - L_2 = Q_2 \\ \text{and} & Q_2 - L_3 = Q_3, \quad \text{and so on.} \end{array}$$

In this way column Qx is filled in.

$$Ex = \frac{Qx}{Lx}$$

Or $\frac{Q_0}{L_0}$ = mean duration of life, or the curtate expectation of life.

$\frac{Q_1}{L_1}$ = expectation of life at age one year, or the number of years more a person is expected to live on reaching the first year of life.

$\frac{Q_2}{L_2}$ = expectation of life at age two years.

In this way column Ex is filled in.

The real expectation of life is the curtate expectation of life plus half a year, as some of those who died in any given year in all probability nearly completed that year, and so on an average they all lived half a year longer than the curtate expectation of life indicates.

The Probable Duration of Life is the age at which a given number of live persons at birth is reduced one-half, or, in other words, the chances of dying before and after that age are equal. It differs from the Mean Duration of Life inasmuch as it takes into account only one-half of the million, whereas the Mean Duration of Life considers the whole million. The Mean Age at Death and the Mean Duration of Life are not the same, as the former only considers the ages of those who have died, and not the ages of those still living. It may be a fluctuating quantity, and determined by agencies over which we have no control. If an epidemic carried off a large number of young children, the Mean Age at Death would inevitably be reduced, but the Mean Age of the living would not appreciably be altered. Therefore we may say that the Mean Duration of Life takes into account not only those who have died, but also those still living. Of course, they are the same in a life table, as every one in the life-table population has been duly considered from birth to death. In England and Wales the Mean Duration of Life is about forty-four years, and the Probable Duration of Life about fifty-three years.

The late Dr. Farr showed that in the absence of life tables

the Mean Duration of Life could be estimated approximately by the following formula—

$$\left(\frac{1}{3} \times \frac{1000}{\mathrm{B}}\right) + \left(\frac{2}{3} \times \frac{1000}{\mathrm{D}}\right).$$

B = the birth-rate per 1000 of the population.
D = the death-rate ,, ,, ,, ,,

Example.—A town has a birth-rate of 25 per 1000 and a death-rate of 18 per 1000. What is the Mean Duration of Life ?

$$\begin{aligned} &= \left(\frac{1}{3} \times \frac{1000}{25}\right) + \left(\frac{2}{3} \times \frac{1000}{18}\right) \\ &= 13{\cdot}3 + 37 \\ &= 50{\cdot}3 \text{ years.} \end{aligned}$$

Willich's formula gives the Expectation of Life at any age A.

$$x = \frac{2}{3}(80 - \mathrm{A}).$$

Example.—What is the Expectation of Life at the age 20 years ?

$$\begin{aligned} x &= \frac{2}{3}(80 - 20) \\ &= 40 \text{ years.} \end{aligned}$$

Life Capital.—This expression refers to the future lifetime of an individual, or of an entire population. If the Mean Expectation of Life for a particular age group be multiplied by the number of persons living in that group, the Life Capital for that specific population is obtained. Let this be repeated for all age periods, when we have the total Life Capital for the whole community.

Example—

Age period.	Mean population of the community.	Mean expectation of life in groups in ages.
0–5	5415	52
5–10	5314	51
10–15	5078	48
15–20	4835	43
20–25	4461	39
25–35	4013	33
35–45	3756	29
45–55	3448	20
55–65	2673	13
65–75	1514	9
75–85	637	6
85 and upwards	83	4

Life Capital for	0–5	= 5415 × 52 =	281,580
,, ,, ,,	5–10	= 5314 × 51 =	271,014
,, ,, ,,	10–15	= 5078 × 48 =	243,744
,, ,, ,,	15–20	= 4835 × 43 =	207,905
,, ,, ,,	20–25	= 4461 × 39 =	173,979
,, ,, ,,	25–35	= 4013 × 33 =	132,429
,, ,, ,,	35–45	= 3756 × 29 =	108,924
,, ,, ,,	45–55	= 3448 × 20 =	68,960
,, ,, ,,	55–65	= 2673 × 13 =	34,749
,, ,, ,,	65–75	= 1514 × 9 =	13,626
,, ,, ,,	75–85	= 637 × 6 =	3,822
,, ,, ,,	85, etc.	= 83 × 4 =	332
			1,541,064

Therefore the total Life Capital of the entire population of 41,227 is 1,541,064 years, and $\frac{1,541,064}{41,227} = 37{\cdot}3$ years, is the average Life Capital of each member of the community.

Let it be assumed that after a lapse of twenty years the individual Life Capital of the population of the same community is thirty-nine years, that is, owing to the improved conditions, the Mean Expectation of Life has been raised; then obviously there has been a gain of 1·7 years of Life Capital per unit of the population.

The **statistical evidence** that may be taken **to compare the healthiness of two or more communities** is the Corrected death-rate, the Zymotic death-rate, the Infantile mortality rate, the Phthisis death-rate, the Mean Age at Death, and the Mean Duration of Life.

The Corrected death-rate is generally very good, but it is liable to falsify impressions, as the rate may be raised by a sporadic outbreak of some imported disease, which by the utmost vigilance of those in authority could not have been avoided.

The Zymotic death-rate is held to be an index of the sanitary conditions which prevail, but again owing to the importation of some infectious disease, or to the cyclical variation of disease, despite general healthy conditions, the rate might be high. On the other hand, a continued high rate would imply that some internal cause was at fault.

The Infantile mortality rate is often very useful, as children under one year more easily succumb to the diseases favoured by insanitary environment. An implicated milk supply or a hot summer might very easily raise the rate, thereby leading one to erroneous conclusions.

The Phthisis death-rate on the whole is fairly good, as it may be taken to indicate unhealthy and damp conditions, and as it is not affected to any material extent by seasonal or cyclical prevalence. Phthisis-genetic occupations, however, must be

taken into account, as obviously they would swell the rate, quite independent of everything else.

The Mean Age at Death is valueless, as has already been pointed out.

The Mean Duration of Life as obtained from a life table is probably the best evidence.

DEATH-RATES, ETC., FOR ENGLAND AND WALES

	1905.	1910.	1914.	1917.	
Mid-year population	34,152,977	35,796,289	36,960,644	33,711,000	civilian population
Males	16,502,094	17,313,221	17,877,052	14,085,300	
Females	17,650,883	18,483,068	19,083,632	19,625,700	
Marriage rate	15·3	15·0	15·9	13·8	per 1000 of the population
Births	929,293	896,962	879,096	668,364	
Males	472,886	457,266	447,184	341,361	
Females	465,407	439,696	431,912	326,985	
Birth-rate	27·2	25·1	23·8	17·8	
Deaths	520,031	483,247	516,742	498,922	
Males	267,601	249,016	267,359	262,215	
Females	252,430	234,231	249,383	236,707	
Death-rate	15·2	13·5	13·9	14·4	
Deaths under 1 year	118,949	94,579	91,971	64,483	
Infant Mortality rate	128	105	105	96	per 1000 registered births
Typhoid fever	0·089	0·053	0·046	0·028	per 1000 of the population
Measles	0·32	0·232	0·247	0·308	
Scarlet fever	0·112	0·066	0·077	0·022	
Whooping-cough	0·22	0·246	0·218	0·134	
Diphtheria and croup	0·174	0·122	0·16	0·133	
Influenza	0·204	0·182	0·161	0·213	
Erysipelas	—	—	0·031	0·017	
Tuberculosis (all forms)	1·632	1·434	1·361	1·624	
Phthisis	1·14	1·015	1·045	1·228	
Cancer—					
Males	0·756	0·856	0·971	1·263	per 1000 males
Females	1·005	1·07	1·161	1·173	,, females
Pneumonia	1·299	1·11	1·084	1·144	,, population
Small-pox	116 deaths	19 deaths	4 deaths	3 deaths	
Deaths assigned to pregnancy	4·2	3·56	4·17	3·89	per 1000 registered births

All rates for 1917 were calculated on the civilian population only, with the exception of the Marriage-rate and the Birth-rate, which were calculated on an estimated civil and services' population of 37,578,234.

STATISTICS

The following signs should be remembered—

M = mean.
N = number of terms or total cases.
Σ = the sum of.
σ = standard deviation.
r = coefficient of correlation.
Pe = probable error.

The **mean** of a series is the sum of the observations divided by the number of observations;

$$\text{or} \quad M = \frac{x^1 + x^2 + x^3 \ . \ . \ .}{N}$$

$$\text{or} \quad M = \frac{\Sigma x}{N}.$$

The mean of two means is not $\frac{M_1 + M_2}{2}$.

Let there be N_1 observations with M_1, and N_2 observations with M_2.

Then— $$M = \frac{(N_1 \times M_1) + (N_2 \times M_2)}{N_1 + N_2}.$$

Proof—
$$N_1 = x^1 + x^2 \ . \ . \ .$$
and
$$N_2 = y^1 + y^2 \ . \ . \ .$$
$$M_1 = \frac{x^1 + x^2 \ . \ . \ .}{N_1}$$
and
$$M_2 = \frac{y^1 + y^2 \ . \ . \ .}{N_2}$$

∴ the mean of M_1 and M_2

$$= \frac{x^1 + x^2 \ . \ . \ . + y^1 + y^2 \ . \ . \ .}{N_1 + N_2}.$$

Example.—The death-rates per thousand living persons in England and Wales for the ten years 1881–1890 were—

1881	18·8
1882	19·6
1883	19·6
1884	19·7
1885	19·2
1886	19·5
1887	19·1
1888	18·1
1889	18·2
1890	19·5
Mean	19·13

Now the mean of the first seven years is 19·36, and of the last three 18·6. If the mean of these two is calculated thus—

$$\frac{19{\cdot}36 + 18{\cdot}6}{2} = 18{\cdot}98$$

we see we do not get the true mean rate for the ten years.

On applying the formula we obtain—

$$\frac{(19{\cdot}36 \times 7) + (18{\cdot}6 \times 3)}{7 + 3} = 19{\cdot}13$$

which is the correct mean.

The relative values of the two series are not directly proportional to the total cases of each series, but to the square roots of the number of units of observation. If in one series there were 25 cases, and in another series 100 cases, their values, therefore, are not as 25 is to 100, but as the $\sqrt{25}$ is to the $\sqrt{100}$, or as 1 is to 2; that is, the second series is twice as likely to represent the true value as is the first.

The "method of successive means" shows that when only a limited number of observations is available, it is unwise to attach any importance to the result.

Example—

		Excess above the mean.
25 21	Mean of the first two is 23·0	8·0
15	,, ,, ,, three ,, 20·3	5·3
18	,, ,, ,, four ,, 19·7	4·7
16	,, ,, ,, five ,, 19·0	4·0
14	,, ,, ,, six ,, 18·1	3·1
13	,, ,, ,, seven ,, 17·4	2·4
11	,, ,, ,, eight ,, 16·5	1·5
10	,, ,, ,, nine ,, 15·7	0·7
7	,, ,, ,, ten ,, 15·0	0·0

The value of a mean is measured by its "**standard deviation,**" or its "**index of variability,**" for if there is much divergence between the mean and the terms, or if many of the terms are numerically much removed from the mean, then the mean is unreliable.

Example.— A. $4 + 5 + 6 = M5$.
B. $1 + 3 + 11 = M5$.

A. series is clearly more exact than is B. series, because the average deviation of the terms from the mean is less in the case of A. than in the case of B.

Another way of expressing its value is to compare the mean with the two observations which represent the extremes.

Example.— A. Lowest unit of observation = 5
Highest ,, ,, ,, = 25
Mean = 12
B. Lowest unit of observation = 8
Highest ,, ,, ,, = 17
Mean = 12.

B. is the more valuable series, on the assumption that the total number of cases in each was the same. But this is open to the strong objection that, although there is less difference between the two extreme observations in the case of B. than in the case of A., there might conceivably be a greater number of terms approximating to the mean in A. series than in B. In that event A. would constitute the more reliable mean. From this we are compelled to calculate, not the amount which any single observation deviates from the mean, but the average deviation of all the terms from the mean of the series.

The standard deviation may be defined as the square root of the arithmetic mean of the squares of the deviations from the mean of the series.

Required to find the standard deviation of the following numbers: 12, 11, 1, 5, 8, 5, 4, 3, 9, 2.

Step 1. Find the mean of the terms.
„ 2. Determine the deviation of each term from the mean.
„ 3. Square these deviations.
„ 4. Add them together.
„ 5. Find the square root of the sum; the answer is the standard deviation.

This may be written as follows—

		Deviations.	Deviations squared.
12 − 6	=	+ 6	36
11 − 6	=	+ 5	25
1 − 6	=	− 5	25
5 − 6	=	− 1	1
8 − 6	=	+ 2	4
5 − 6	=	− 1	1
4 − 6	=	− 2	4
3 − 6	=	− 3	9
9 − 6	=	+ 3	9
2 − 6	=	− 4	16
M. = 6			130

$$\therefore \quad \frac{130}{10} = 13, \text{ and } \sqrt{13} = 3{\cdot}6 = \sigma$$

$$\therefore \quad \sigma = \sqrt{\frac{\Sigma d^2}{\mathrm{N}}}.$$

It will be understood from what has been said that two means without their standard deviations are not comparable. In a similar manner, two standard deviations will not admit of a comparison being drawn between them, unless their means coincide. Supposing the means of two series are 15 and 5, with standard deviations of 2 and 1 respectively, the mean of 15 may be regarded as being nearer to the true mean than is 5 in its series, although the standard deviation of the former is twice that of the latter. This is obvious, as the relationship between M and σ is as 15 is to 2 in the one case, and as 5 is to 1 in the other. Hence it is a common practice to reduce the σ to a common form by calculating a "coefficient of variation," that is, to state the standard deviation as a percentage of the mean, or—

$$\text{Coefficient} = \frac{100 \times \sigma}{\mathrm{M}}.$$

In this way two coefficients proportionately indicate the variabilities of the two series.

The **Probable Error** (Pe) of the mean is expressed as $\dfrac{0{\cdot}6745 \times \sigma}{\sqrt{\mathrm{N}}}$.

If $\quad \mathrm{M} = 35{\cdot}3$, N 50, and σ 4·8,

then $\quad \mathrm{Pe} = 0{\cdot}6745 \times \dfrac{4{\cdot}8}{\sqrt{50}} = 0{\cdot}45.$

This means that it is equally probable that the mean of another fifty cases would differ from 35·3 by a quantity greater or less than 0·45. The mean should be at least three times its Pe.

Poisson's rule is another way of expressing the possible error. If in N cases of typhoid fever, m cases recover and n cases die, then the chance of recovery $= \dfrac{m}{\mathrm{N}}$ and the chance of dying $= \dfrac{n}{\mathrm{N}}$.

$$\therefore \frac{m}{\mathrm{N}} + \frac{n}{\mathrm{N}} = 1.$$

If N is a very high number, then $\dfrac{m}{\mathrm{N}}$ may be regarded as the true probability of recovery. If, on the other hand, N is numerically small, then it is almost certain that $\dfrac{m}{\mathrm{N}}$ would be a different fraction if another N cases were taken.

The formula is—

$$\frac{m}{\mathrm{N}} \text{ or } \frac{n}{\mathrm{N}} = \pm 2 \times \sqrt{\frac{2 \times m \times n}{\mathrm{N}^3}}.$$

It is obvious that it must be plus or minus, because as the chance of recovery is increased, so the chance of dying must be decreased by the same amount.

Example.—There were 100 cases of typhoid fever; 70 recovered and 30 died. What is the possible error?

Substituting values, we get—

$$\frac{70}{100} \text{ or } \frac{30}{100} = \pm 2 \times \sqrt{\frac{2 \times 70 \times 30}{100^3}}$$
$$= \pm 2 \times \sqrt{\frac{4200}{1{,}000{,}000}}$$
$$= \pm 0{\cdot}13 \text{ (nearly).}$$

$\therefore$ the chance of recovery might have been increased by 0·13, that is, to $\dfrac{83}{100}$, or decreased by 0·13, that is, to $\dfrac{57}{100}$. The recoveries in another 100 cases might have been 83 or 57, with 17 or 43 deaths.

The **Median** and **Mode** are two terms used very commonly with the mean. If a series of terms be arranged in order of their magnitude, the value of the central term is the Median,

for it is plain that the chance of another case falling on either side of that central term is absolutely equal. With a frequency curve it is that variable which divides the curve into two equal parts. The mode is that event which is most likely to happen (from "*la mode*" the fashion). A cricketer may be a most consistent scorer, but occasionally he will make a very high score. It is quite possible, therefore, that the score which he apparently is most likely to make might not be his average. It may be expressed by the following equation—

$$\text{Mode} = \text{Mean} - 3\,(\text{Mean} - \text{Median}).$$

If a frequency distribution, that is a curve indicating the frequency of certain events, be symmetrical, the Mean, Median and Mode are the same, but they do not agree if the curve is "askew" or asymmetrical.

Correlation.—By this is meant that a relationship exists between two phenomena which are associated. If two curves be drawn, one indicating the incidence of summer diarrhœa, and the other variations of temperature, it will be observed that they run more or less parallel. The relationship in this case is positive, because one curve follows the track of the other. On the other hand, the relationship between the average wage earned by agricultural labourers and the percentage number in receipt of poor law relief is negative, because as the wages increase, recipients of poor law relief numerically decline.

If it could be said that perfect positive correlation existed between the two phenomena, then the "coefficient of correlation," usually shown as r, would be 1; if the correlation is perfect, but on the negative side, then r is -1, where 0 indicates no relationship at all. It may be rightly assumed that perfect correlation is impossible; therefore r is always a fraction, and the more nearly perfect the relationship is, the nearer r is to 1 or -1, according to whether it is positive or negative.

The following very simple example will serve to show the method adopted for calculating r. It must be emphasized that it is only an example; the data are totally inadequate for determining the relationship between the height and weight of boys.

Let the following be the height and weight of ten boys—

Height in inches.	Weight in pounds.
60	98
59	98
59	95
58	101
57	91
57	90
56	84
54	83
52	82
48	78

First find the standard deviations of height and weight—

Height.	m.	d.	d^2.		Weight.	m.	d.	d^2.
60	− 56	4	16	. .	98	− 90	8	64
59	− 56	3	9	. .	98	− 90	8	64
59	− 56	3	9	. .	95	− 90	5	25
58	− 56	2	4	. .	101	− 90	11	121
57	− 56	1	1	. .	91	− 90	1	1
57	− 56	1	1	. .	90	− 90		
56	− 56			. .	84	− 90	− 6	36
54	− 56	− 2	4	. .	83	− 90	− 7	49
52	− 56	− 4	16	. .	82	− 90	− 8	64
48	− 56	− 8	64	. .	78	− 90	− 12	144
560			124	. .	900			568

$$\therefore \qquad \sqrt{\frac{124}{10}} = 3{\cdot}5 = \sigma \text{ of height}$$

$$\text{and} \qquad \sqrt{\frac{568}{10}} = 7{\cdot}5 = \sigma \text{ of weight.}$$

Now multiply d. of height by d. of weight respectively, as follows—

d. of height.		d. of weight.
4	. . . .	8 = 32
3	. . . .	8 = 24
3	. . . .	5 = 15
2	. . . .	11 = 22
1	. . . .	1 = 1
1	. . . .	
	. . . .	− 6
− 2	. . . .	− 7 = 14
− 4	. . . .	− 8 = 32
− 8	. . . .	− 12 = 96
		236

$$r = \frac{\Sigma(d \times d)}{N\sigma_H\sigma_W}$$

$$= \frac{236}{10 \times 3{\cdot}5 \times 7{\cdot}5} = \frac{236}{262{\cdot}5} = 0{\cdot}89.$$

This coefficient would imply that the relationship was nearly perfect.

$$\text{Pe of } r = 0{\cdot}6745 \times \frac{1 - r^2}{\sqrt{N}}.$$

r must be at least three times its probable error before it is considered to be of any value.

SECTION IX

SANITARY LAW (ENGLAND AND WALES)

MINISTRY OF HEALTH ACT, 1919

THIS Act secures the appointment of a Minister of Health, whose duty it is to prepare, carry out and co-ordinate measures conducive to the health of the people. To him are transferred—

1. All the powers and duties of the L.G.B.
2. All the powers and duties of the Insurance Commissioners.
3. All the powers of the Board of Education regarding the health of expectant mothers and nursing mothers, and of children under five years of age not attending a recognised school.
4. All the powers and duties of the Board of Education with respect to the medical inspection and treatment of children and young persons attending school.
5. All the powers of the Privy Council under the Midwives Act.
6. Such powers of supervising Part I of the Children Act, 1908 (which relates to infant life protection), as have heretofore been exercised by the Secretary of State.

By Order in Council His Majesty may transfer to the Minister—

(*a*) The powers and duties of the Minister of Pensions regarding the health of disabled officers and men after they have left the Service.
(*b*) The powers and duties of the Secretary of State under the Lunacy and Mental Deficiency Acts.
(*c*) Any other powers and duties which relate to matters affecting the health of the people.

The Act further makes provision for the establishment of Consultative Councils in England and Wales. These councils are to advise and assist the Minister, and must consist of persons having practical experience of the matters referred to them. Women are to be included as members.

N.B.—It will be understood throughout the Section on Sanitary Law that, where L.G.B. is mentioned in the various Acts, etc., Ministry of Health must now be substituted.

Abbreviations—

B. of A.	Board of Agriculture.
C.C.	County Council.
C.L.H.	Common Lodging House.
D.C.M.O.	Dairies, Cowsheds, and Milkshops Order.
F.I.	Factory Inspector.
F. & W.A.	Factory and Workshop Act.
H.T.P.A.	Housing, Town Planning Act.
H.W.C.A.	Housing of the Working Classes Act.
I.H.A.	Isolation Hospitals Act.
I.N.	Inspector of Nuisances.
L.A.	Local Authority.
L.G.B.	Local Government Board.
M.O.H.	Medical Officer of Health.
P.H.A.	Public Health Act, 1875.
P.H.A. (A.) A.	,, ,, ,, (Amendment Act).
R.P.P.A.	Rivers Pollution Prevention Act.
S.A.	Sanitary Authority.
S.F.D.A.	Sale of Food and Drugs Act.
S.I.	Sanitary Inspector.
V.S.	Veterinary Surgeon.

Sanitary Authorities—

County = County Council = { *Urban districts* = Urban District Council; *Rural districts* = Rural District Council; *Parishes* (of over 300 population) = Parish Council. }

A " Parish meeting " is a meeting of the electors in any parish. It is really " the unit of Local Government."

County Boroughs	Town Council.
Municipal Borough	Municipal Council.
Port	Port Sanitary Authority.

Sanitary Duties

(*a*) **County Council.**—Administers R.P.P.A., 1876, I.H.A., 1893, Midwives Acts, 1902 and 1918. Acts as supervising and appeal authority in the county, and has special duties in connection with tuberculosis, maternity and child welfare, and venereal disease schemes.

(*b*) **County and Municipal Borough and Urban District Councils.** Administer practically all the Health Acts.

(*c*) **Rural District Council.**—Administers most of the Acts dealt with by U.D.C.'s, with certain exceptions under the P.H.A., 1875, and the H.W.C.A., 1890, and has distinct powers under the P.H. (Water) A., 1878. A rural S.A. may at times be invested by the L.G.B. with the powers of an urban S.A.

(*d*) **Parish Council.**—Usually has certain powers conferred on it.

MEDICAL OFFICERS OF HEALTH

County M.O.H.—Appointment compulsory under the H.T.P.A., 1909. His duties, as defined by the County M.O.H. (Duties) Order of 1910, include—

1. Visiting the various districts of his county, and consulting with the district Medical Officers.

2. Inquiring into, and reporting on, fever hospital accommodation.

3. Furnishing special reports, and seeing that the reports of the district Medical Officers contain adequate information on important matters.

4. Compiling an annual report on the sanitary state of his county, which must include—

(*a*) A digest of all the reports of the district M.O.H.'s.
(*b*) Adequacy of hospital accommodation.
(*c*) Administration of the H.W.C.A.'s.
(*d*) Water supply in the various districts.
(*e*) Pollution of streams.
(*f*) Administration of Midwives Acts.
(*g*) Administration of S.F.D.A., when applicable.

Two copies of all reports to be sent to the L.G.B., one copy of annual report to every District Council, and three copies of any special report to the District Council affected.

M.O.H. (Urban or Rural).—Appointment compulsory under P.H.A., 1875, Secs. 189 and 190.

The following are some of the provisions contained in the Sanitary Officers Order, 1910—

If the district has a population greater than 50,000, the M.O.H. must hold a *registered* diploma of Public Health or State medicine.

The L.G.B. must approve the appointment when they contribute towards the salary, and such appointment cannot be terminated without their consent.

Duties.—1. Must keep himself informed by inspection and otherwise of all influences likely to affect health, and inquire into the cause and distribution of diseases.

2. Must advise the Council in all matters relating to health, and give any certificates necessary for legal action.

3. Must visit without delay any place where a dangerous infectious disease has broken out, and see that all proper precautions are being taken.

4. Direct the work of the S.I.'s and take all necessary steps in dealing with nuisances.

5. Carry out the provisions of the P.H.A. regarding unfit food.

6. Inquire into all offensive trades.

7. Attend at the Council offices at times appointed by the Council.

8. Keep all necessary books provided, with entries of visits paid, actions taken, etc., and produce them when required by the Council.

9. Send every Monday to the L.G.B. and County M.O.H. a

return of all cases of infectious diseases notified during the previous week.

10. Compile an annual report dealing with—

(*a*) All matters affecting the health of his district, and the preventive measures taken.

(*b*) An account of the work of the S.I.'s.

(*c*) Conditions affecting the wholesomeness of milk and other foods produced or sold in his district.

(*d*) Full details of the water supply.

(*e*) Pollution of rivers and streams.

(*f*) Approximate numbers of each type of privy and closet, the sufficiency of drainage, sewerage, and sewage disposal, and the efficiency of the methods of removal of house refuse, etc.

(*g*) Housing, and any action taken under H.T.P.A., 1909, *e. g.* number of closing orders, etc.

(*h*) Vital statistics of the district.

(*i*) Administration of the Midwives Acts in the case of County Boroughs.

In addition he must report to the L.G.B. any case of plague, cholera, or small-pox, or any serious outbreak of epidemic disease. Three copies of each annual report, and one of each special report, must be sent to the L.G.B., and one copy of all reports to the C.C. In County Boroughs a copy of that part of the report dealing with the administration of the Midwives Acts must be sent to the Privy Council and the Central Midwives Board.

Port M.O.H. Sanitary Officers (Ports) Order, 1910.—Has to deal with everything affecting the health of those on board ship within his area, and is responsible for the control of dangerous nfectious disease brought within his area by ships.

Must report to the L.G.B. and C.C. any case of plague, cholera, or small-pox, or any serious outbreak of epidemic disease on ship-board, and must notify the M.O.H. of the port of destination of any vessel which has had such a case on board within his own area.

Must allow no persons to land from an "infected" ship without forwarding their names and addresses to the M.O.H. of the place to which they are going.

Must deal with nuisances on ships as under the P.H.A., 1875.

Has many duties regarding unsound food under the special regulations.

Sanitary Inspectors.—Appointment compulsory under the P.H.A., 1875, Secs. 189 and 190.

Duties.—(Sanitary Officers Order, 1910.)

Under the supervision of the M.O.H. must carry out all inspections of nuisances, etc.

Examination of unsound food, sampling of food and drugs, etc.

Must attend all meetings of Council and Committee when required, and keep a register of all inspections and action taken.

Carry out any work required of him regarding removal of infected patients to hospital and subsequent disinfection.

Furnish an annual report to the M.O.H. of the number and nature of inspections made by him, number of notices sent, and the results of such notices.

BYE-LAWS are laws made by some authority lower than Parliament, *e. g.* a S.A., in regard to some matter specially referred to the authority and not provided for in the law of the land. When made in accordance with the following requirements they are practically as valid as statutes.

Requirements.—1. They must be reasonable and in accordance with the law of the land.

2. They must supplement and not supersede existing statutes.
3. They must be free from all ambiguity and of general application.
4. They must be confirmed by the L.G.B.
5. Penalties for breach must be imposed.

Bye-laws must be made by all S.A.'s regarding common lodging-houses. All urban S.A.'s must make bye-laws regarding slaughter-houses.

Bye-laws may be made regarding (among other matters)—

1. Private scavenging.
2. Prevention of nuisances from snow, filth, etc., and the keeping of animals so as to be injurious to health.
3. Common lodging-houses.
4. Houses let in lodgings.
5. Offensive trades.
6. Public mortuaries.
7. New streets and buildings.
8. Slaughter-houses.
9. Markets.
10. Tents and Vans.
11. Hop and fruit pickers.

Model sets of bye-laws have been issued by the L.G.B. Any of these may be adopted by a S.A. It is only when a S.A. elects to frame bye-laws of its own or alters model bye-laws to suit its own requirements that the approval of the L.G.B. must be obtained.

REGULATIONS as a rule do not require confirmation by the L.G.B., with the exception of (1) those made under Sec. 125, P.H.A., regarding the removal to hospital of infected persons on board ships, and (2) those made under Sec. 17, H.T.P.A., 1909, regarding underground sleeping-places.

Power is given to the L.G.B. to make regulations regarding

various matters, including infectious diseases, foreign meat, dairies, cowsheds, and milkshops, etc.

NUISANCES

Only **statutory nuisances** under the **P.H.A.** are dealt with by the S.A. They are conditions which are, or may be, injurious or dangerous to health.

Such nuisances are (Sec. 91)—

1. Any premises so kept as to be a nuisance or injurious to health.
2. Any pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit so foul or in such a state, etc.
3. Any animal so kept, etc.
4. Any accumulation or deposit which is, etc. (no penalty imposed if it has not been kept longer than is necessary for trade purposes and the best available means have been used for preventing injury to health).
5. Any house or part of a house so overcrowded—whether the inmates are members of the same family or not (300 cubic feet per head for sleeping-rooms only, 400 for living- and sleeping-rooms; half these amounts for children under 10—*vide* L.G.B. Model Bye-laws *re* Houses let in Lodgings).[1]
6. Any factory, workshop, or workplace not kept in a cleanly state, not ventilated so as to render harmless any gases, etc., produced, or so overcrowded, etc. (250 cu. feet per head, 400 for overtime, F.W.A., 1901).
7. Any fireplace or furnace in any manufactory which does not, *so far as practicable*, consume its own smoke, and any chimney (not of a private dwelling) giving forth *black* smoke in such a quantity as to be, etc. Mines and smelting works are excepted.

N.B.—Ships and vessels lying in rivers, harbours, etc., belonging to a S.A. are to be regarded as houses, and the officer in charge as the occupier.

Other nuisances are: Under the H.W.C.A., tents, vans, or sheds so filthy or overcrowded as to be a nuisance or injurious to health.

Under various Acts, railway locomotives not consuming their own smoke, unfenced quarries, and abandoned coal mines.

Under P.H.A. (A.) A., 1907 (adoptive).—1. Any cistern for domestic supply so placed, constructed, or kept as to cause risk to health.

2. Any gutter, drain, etc., of a building causing dampness.
3. Any deposit of material causing dampness in a building.

[1] In the Model Bye-Laws made under Sec. 26. H.T.P.A. 1919 the figures are 360 cubic feet for adults and 250 for children under 10 years—in rooms used wholly or partly as sleeping appartments.

Under P.H. (London) A., 1891.—1. Absence of prescribed water fittings.

2. Any occupied house with insufficient water supply.

3. Any water-closet or drain so constructed or repaired as to be a nuisance or injurious or dangerous to health.

How a Nuisance is Dealt with Summarily.—1. Inspection of district by the S.I.

2. Complaint to the S.A. of existence of a nuisance by an officer of the S.A., any aggrieved person, two householders of the district, a police officer, or relieving officer.

3. Investigation of the complaint by an officer of the S.A., and report to the S.A. Such officers have the right of entry. If refused they can apply to a justice for an order, in which case penalties for obstruction may be obtained.

4. Service of a Statutory Notice by the S.A. on the responsible person. This specifies the nature of the nuisance and calls for its abatement within a certain time. If the responsible person is not to be found, the notice is served on the owner or occupier. (The owner is the person who receives, or would receive, if the premises were let, the " rack rent " of the premises either on his own behalf or as agent for some one else. The " rack rent " is a rent not less than two-thirds of the full net annual value of the property.) The notice may be delivered by hand or sent by registered post to the address. In the case of empty premises it may be posted up on a prominent part of the building. If the nuisance is due to structural defects or if the premises are unoccupied, the notice must be served on the owner. If the responsible person cannot be found, and the owner or occupier is clearly not responsible, the S.A. may abate the nuisance themselves.

5. Should the nuisance remain unabated, or be likely to recur, the S.A. may obtain a summons from a justice—the summons to be applied for within six months of the date of the original offence.

6. If the court is satisfied that, so far, the case has been proceeded with legally and that a nuisance actually exists, it may make a Nuisance Order of one, or all, of the following kinds—

1. Abatement order—to abate the nuisance within a specified time.
2. A prohibition order—to prohibit recurrence.
3. A closing order—to close the premises till fit for human habitation.

7. Penalties of 10*s*. a day for default may be ordered in the case of an abatement order, and 20*s*. in the case of a prohibition order. Expenses may also be recovered by the S.A.

8. The S.A. may themselves enter the premises, deal with the nuisance, and recover expenses from the person on whom the order has been made.

9. In the event of the S.A.'s not taking action, an individual may complain to a justice, who may authorise a constable to act in the matter. Individuals have also the right of appeal to the L.G.B., who may empower a constable to institute proceedings. Such officer has power of entry only with consent or with a justice's warrant.

Under the P.H. (London) A., 1891, a S.I. must send a "written intimation" of the existence of a nuisance to the person concerned as a preliminary to further proceedings. This intimation frequently results in the abatement of the nuisance without further trouble.

OFFENSIVE TRADES

P.H.A., 1875.—These are blood boiler, bone boiler, soap boiler, tripe boiler, tallow melter, and fellmonger, or any other trade of the same nature, *i. e.* dealing with organic matter.

1. No offensive trade may be established within an Urban District without the consent of the S.A.
2. S.A.'s may make bye-laws concerning such trades permitted by them.
3. If the M.O.H., two general practitioners, or ten rate-payers certify that the effluvia from any such trade are a nuisance, the S.A. must take proceedings. The offender will probably endeavour to show that the "best practicable means" have been adopted for preventing the nuisance.

P.H.A. (A.) A., 1907 (adoptive) gives power to a S.A. to declare any trade an offensive one, with the consent of the L.G.B.

Model Bye-laws have been issued regarding various offensive trades. They deal with—

1. Storage of materials in air-tight receptacles.
2. Treatment of all effluvia so as to render them innocuous, *e. g.* by discharge into the open air through a high chimney, or by passage through a fire or condensing apparatus.
3. Daily cleansing of all utensils, floors, etc.
4. Maintenance of floors, walls, etc., in good condition. (Walls should be made of impermeable material to a height of at least 6 feet.)
5. Scraping of walls periodically, and hot lime-washing two or four times yearly, *e. g.* in March, June, September, and October.
6. Efficient drainage and cooling of hot waste liquors before discharge into drains.
7. Facilities for inspection and penalties for default.

SLAUGHTER-HOUSES

P.H.A., 1875 (Sec. 169).—1. Urban S.A.'s may provide slaughter-houses.

2. Within one month after licensing or registration of a

slaughter-house, the owner or occupier must affix a notice "Licensed Sl.-H." or "Registered Sl.-H."

The following provisions of the Towns Improvement Clauses Act, 1847, are incorporated—

3. Slaughter-houses and knackers yards must be licensed (unless so used before the passing of the Act), and registered.

4. Urban S.A.'s *must* make bye-laws regarding slaughter-houses and knackers yards for licensing, registration, and inspection; cleanliness and daily removal of filth; sufficient water supply, and prevention of cruelty.

5. Any one guilty of killing or dressing cattle contrary to the Acts or bye-laws may have his licence suspended for two months, or, in the case of registered premises only, slaughtering may be forbidden for two months. Licence or registration may be revoked for further offence.

6. Right of entry, inspection and seizure of unfit cattle, etc.

P.H.A. (A.) A., 1890 (adoptive).—1. Licences remain in force one year or more as the Urban S.A. may decide.

2. Any change of occupation of a licensed or registered slaughter-house must be notified to the S.A.

3. Licence may be revoked by a justice, if occupier is convicted under the unsound food section of the P.H.A., 1875.

Memorandum by the L.G.B. regarding site and structure—

1. Not within 100 feet of any dwelling; direct communication with external air on two sides.

2. Cattle lairs not within 100 feet of any dwelling.

3. No part below the surface of adjoining ground.

4. Slope of entrance not more than 1 in 4, and never through a dwelling-house or shop.

5. No room or loft above.

6. Sufficient tank for water, bottom at least 6 feet above floor.

7. Impermeable floor drained to a gully, properly trapped and covered with a grating of bars not more than $\frac{3}{8}$ inch apart.

8. Smooth impervious walls inside.

9. No closet, privy, or cesspool to be within, or communicate directly with, a slaughter-house.

Model Bye-laws.—1. Every applicant for a licence to erect a slaughter-house must give full details as to site, structure, etc.

2. Every applicant for a licence to occupy, must in addition give name and address of owner of premises, and the full conditions of occupation.

3. Once licensed, the person may apply in writing for registration of premises.

4. Full inspection must be made before registration.

5. Every animal must have sufficient water, and all precautions, *e. g.* fastening of the head, must be taken to prevent pain.

6. Ventilation and drainage to be maintained in good order.

7. Walls and floor to be kept clean, and washed within three hours of any slaughtering. The walls to be washed with hot lime between the 1st and 10th of March, June, September and December.

8. No dogs to be kept. No animals to be admitted unless intended for slaughter for food. All animals to be kept in proper lairs, and no longer than absolutely necessary.

9. Skins, offal, etc., to be removed within twenty-four hours—storage in non-absorbent receptacles, which must be kept clean when not in use.

10. Sufficient water supply to be provided for cleansing.

SANITARY CONVENIENCES

P.H.A., 1875.—1. All new or rebuilt houses must have sufficient water-closet, earth-closet, or privy accommodation, and a properly covered ashpit.

2. Urban S.A.'s may provide public conveniences and ashpits.

3. All S.A.'s must see that all drains, water-closets, earth-closets, ashpits, and cesspools in their district are properly constructed and kept.

4. S.A. may require that sufficient closets for the separate use of each sex be provided in factories.

5. (Sec. 41). On a written complaint that any drain, water-closet, earth-closet, privy, ashpit or cesspool is a nuisance, the S.A. may in writing empower their inspector to enter the premises (after twenty-four hours written notice to the occupier) and open the ground and examine any drains, closets, etc. If no defect is present the S.A. must make good any damage; if defects are found, the S.A. must serve a notice on the owner ordering the necessary work to be done within a specified time. Penalty of ten shillings a day for default, and the S.A. may do the work and recover expenses.

6. An urban S.A. may make bye-laws regarding water-closets, earth-closets, privies, and ashpits, in connection with buildings.

P.H.A. (A.) A., 1890 (adoptive).—1. When a sanitary convenience is used in common by the occupants of two or more separate dwelling-houses, any one injuring or improperly fouling it is liable to a penalty of ten shillings. If the responsible person cannot be found, every person using it is liable to a penalty.

2. Sufficient separate conveniences must be supplied in all factories.

3. A rural S.A. adopting this Act has the same powers regarding the making of bye-laws under the P.H.A., 1875, as an urban S.A.

Model Bye-laws (Under Sec. 157, P.H.A.)—

Water-closets.—1. At least one side to be an external wall, if closet within a building.

2. Window at least 2 feet by 1 foot clear of the frame, set in an external wall. In addition an air-brick or air-shaft must be provided.

3. Separate cistern of adequate capacity to supply water-closet, thus cutting off any direct water connection with the main. Suitable flushing apparatus. Proper closet-pan retaining a sufficient quantity of water, and so made that filth will fall clear of the sides and directly into the water. It must be kept clean. Containers and D traps not allowed.

Earth-closets, if within a building, must be placed, lighted, and ventilated as water-closets.

1. Easily accessible receptacle, water-tight and non-absorbent. Fixed receptacles of such size as to require emptying every three months—in no case greater than 40 cubic feet. The bottom of the receptacle to be 3 inches above the ground adjoining.

2. No drainage or waste water must enter receptacle.

3. An apparatus to be provided for applying dry earth to cover filth.

Privies.—1. At least 6 feet from a building where persons are employed, and 40 feet away from any well or water supply. Must not be in such a position as to pollute any water supply.

2. Accessible for cleansing, no filth to be carried through any house during cleansing.

3. Ventilation opening near the roof; floor paved, at least 6 inches above level of adjoining ground, and with a fall of $\frac{1}{2}$ inch per foot towards the door.

4. If receptacle fixed, arrangements to be made for frequent application of ashes, dust, etc., to the filth. Water-tight and non-absorbent. Waste waters to be excluded. Capacity not greater than 8 cubic feet. Bottom at least 3 inches above level of ground. Seat to be adjustable for emptying purposes.

5. If receptacle movable, space beneath the seat to be built of 9-inch brickwork rendered in cement. Floor 3 inches above level of ground. Receptacle not more than 2 cubic feet. Seat to afford access for removal of receptacle.

6. No communication of privy with drain.

Ashpits.—As regards position and access, same as privies. Not more than 6 cubic feet, *i. e.* to hold not more than a week's rubbish. Made of 9-inch brickwork rendered in cement. Proper roof and door. Must be ventilated. Must not communicate with a drain.

N.B.—Ashpits are now usually replaced by sanitary dust-bins.

Cesspools.—1. At least 50 feet from a house and 60 to 80 feet from a water supply.

2. Constructed of good brickwork rendered in cement, with at least 9 inches of well-puddled clay behind and below. Properly covered and ventilated and accessible for cleansing.

3. No communication with a sewer.

Conversion of Privies, etc., to Water-carriage System

P.H.A., 1875.—Under Sec. 91 there is power to deal with privies, etc., if a nuisance is proved, and, under Sec. 35, etc., all new or rebuilt houses must have sufficient water-closet, etc., accommodation.

P.H.A. (A.) A., 1907 (adoptive).—Under Sec. 39 the S.A., on the report of the M.O.H. or Surveyor, have power to compel an owner to convert an *insufficient* privy or earth-closet into a water-closet if sewers and drains are available. Even where the existing privy, etc., is not insufficient, but where a system of drains and sewers has been laid down, the S.A. may, by written notice, order the conversion. In default they may do the work themselves, bearing the whole cost if a pail-closet is being converted, or half the cost if other than a pail-closet is concerned.

SEWERS AND DRAINS

Sewers

P.H.A., 1875.—1. All sewers are vested in, and controlled by, the S.A., except (*a*) those already built for profit, (*b*) those draining or irrigating land under a private Act, and (*c*) those under Commissioners of Sewers appointed by the Crown (as in the City of London).

2. S.A. may purchase any sewers, and may carry sewers through, across, or under streets and buildings.

3. S.A. must provide sewers when necessary, must keep them in repair, and see that they are so constructed as not to be a nuisance.

4. Any owner or occupier within the district has the right, after notice to the S.A., to connect his drains with the sewer, subject to the regulations of the S.A.

5. Persons outside the district may use the sewers by arrangement with the S.A.

6. No buildings to be erected over a sewer without the written consent of the S.A.

P.H.A. (A.) A., 1890 (adoptive).—Penalties provided for: (1) throwing into a drain or sewer anything likely to hinder the flow or damage the sewer; (2) turning into a drain or sewer any chemical refuse or fluid above 110° F.

R.P.P.A., 1876.—Trade effluents must be admitted to sewers provided they do not injure the sewers, or prevent proper disposal of the sewage.

Disposal of Sewage

P.H.A., 1876.—1. Sewage must be purified before being discharged into a stream, watercourse, canal, pond or lake.

2. S.A. may construct works, lease land, etc., for the treatment of sewage.

3. No nuisance must be caused.

Drains

Definitions. P.H.A., 1875.—"Drain" means any drain receiving the drainage of one house, or of premises within the same curtilage (boundary wall). All other such pipes are sewers. This drain is repairable at the owner's expense, whereas all sewers are repairable at the cost of the S.A.

P.H.A. (A.) A., 1890 (adoptive).—If several houses belonging to different owners drain into one pipe, prior to entering the sewer, such pipe is a drain, and therefore repairable at the owner's expense. If the houses, however, belong to one owner, such pipe is a sewer, and repairable at the cost of the S.A.

These types of drain are known as "combined drains," and have caused much confusion in legal cases.

In London "combined drains" are drains if, prior to their construction, plans were submitted to, and approved by, the S.A.

P.H.A., 1875.—1. Owners must provide a properly covered drain emptying either into a sewer, if one is available within 100 feet of the house, or, if not, into a proper cesspool, not situated under the house. The S.A. may prescribe the materials, sizes, levels, and fall. In default, the S.A. may carry out the work and recover expenses.

2. Penalty of £50 for building or rebuilding a house, or occupying such house, without first seeing that these provisions have been carried out.

3. On written application of any one (if P.H.A. (A.) A., 1907, is adopted, on the report of the S.I. as well) that any drain, water-closet, earth-closet, privy, ashpit, or cesspool is a nuisance or injurious to health, the S.A. may, after twenty-four hours written notice to the *occupier* of the premises, empower their inspector in writing to enter, open the ground, and examine the drains, etc. If no defect found, S.A. must make good any damage. If defects found, the S.A. must serve a written notice on the *owner* to do the work within a specified time. Penalty for default, and the S.A. may do the work and recover expenses.

P.H.A. (A.) A., 1907 (adoptive).—Proper sinks or drains or necessary appliances for carrying off refuse water may be demanded within twenty-eight days after written notice to the owner or occupier.

London.—The Metropolis Management Acts give the L.C.C. charge of the main sewers and the disposal of the sewage. The Borough Councils are the authorities for the branch sewers, but no new sewers may be constructed without the consent of the L.C.C. In the City of London the authorities for all sewers

are the Commissioners of Sewers (who also act as the S.A. for the City).

No drain being repaired or newly constructed may be closed until after forty-eight hours' notice to the S.A. that the drain is ready for inspection and testing.

Model Bye-laws (under Sec. 157, P.H.A.).—1. The sub-soil of all sites must be effectually under-drained by earthenware field-pipes, which may communicate with a drain or cesspool only by means of a proper trap.

2. The lowest storey must be sufficiently above the level of the sewer to permit of drainage.

3. Drains carrying sewage must be at least 4 inches internal diameter, of impervious material, laid in a bed of concrete and with water-tight joints.

4. Must not pass under a building, but, if no other route is practicable, the drain must pass direct for the whole distance, and be embedded all round in 6-inch concrete.

5. Must be ventilated at each end of the portion under the building.

6. All inlets not intended for ventilation must be trapped.

7. The main drain must be trapped as far as possible from the building before it enters the sewer (disconnecting trap).

8. Every branch drain must join any other drain obliquely and in the direction of the flow.

9. *Ventilation.*—A drain must have at least two untrapped openings—one opening (the inlet) about ground-level on the house side of the disconnecting trap, and the other (the outlet) at the head of the drain, and carried at least 10 feet above ground (usually the soil pipe), or to such height that no foul gas can escape into the building. This shaft must be at least 4 inches in diameter, and of no less sectional area than the drain itself. It must have no bends. Each opening must have a suitable grating. If necessary, the positions of the inlet and outlet may be reversed.

10. Only water-closet inlets to the drain allowed inside the building.

11. Soil pipes must be at least 4 inches in diameter, fixed outside, and carried up full bore above the eaves.

12. No trap between the soil pipe and the drain—the water-closet trap is the only one allowed in any part of the soil pipe.

13. Waste-water pipes must be taken through an external wall and made to discharge in the open over a channel leading to a trapped gully at least 18 inches distant.[1]

14. Slop sinks to be treated as water-closets.

SCAVENGING

P.H.A., 1875.—1. Every S.A. may, or when required by the

[1] Such pipes should rather discharge into the trapped gulley by a side inlet beneath the grating.

L.G.B. must, remove household refuse, and cleanse privies, cesspools, etc. Penalty if S.A. neglect to do this within seven days of receiving notice from occupier.

2. S.A.'s not undertaking such cleansing (including pavements) may make bye-laws imposing these duties on the occupiers. Any urban S.A. may also make bye-laws for prevention of nuisances from snow, filth, dust, ashes, and rubbish, and for the prevention of keeping of any animals in premises so as to be injurious to health.

3. Every urban S.A., or rural S.A. empowered by the L.G.B., may cleanse the streets. L.G.B. may render this compulsory. Watering the streets is optional.

4. On the certificate of the M.O.H. or two practitioners that any house is so filthy or unwholesome as to affect health, or that its cleansing would tend to prevent or check infectious disease, the S.A. must notify the owner or occupier to cleanse the house. Penalty for default, and the S.A. may do the work and recover expenses.

5. The Inspector of Nuisances of any urban S.A. may serve a notice on any occupier for the removal of any accumulation of manure or any other offensive matter. In default, the S.A. may sell the refuse, and recover expenses from the proceeds. The occupier is liable for any deficit.

6. Any urban S.A. may by public notice call for the periodical removal of manure, etc., from stables.

P.H.A. (A.) A., 1890 (adoptive).—Any urban S.A. may make bye-laws—

(*a*) For prescribing the time for the removal through streets of fæcal or any noxious material.

(*b*) For providing properly covered carts for such work.

(*c*) For compulsory cleansing of places where any such matter has been spilt.

P.H. (London) A.—S.A.'s must remove house refuse and cleanse privies, etc., trade refuse also on payment.

Model Bye-laws (under Sec. 44, P.H.A., 1875) for private scavenging. The occupier (*a*) must cleanse pavements adjoining his house daily except Sundays, (*b*) must remove house refuse and cleanse ashpits weekly; cleanse pail-closets and all privies weekly; fixed receptacles, earth-closets, and cesspools three-monthly.

So far these bye-laws apply to either urban or rural S.A.'s; the following apply only to urban S.A.'s—

1. The occupier (*a*) must remove all snow from the pavements, and must not block the carriage way with the accumulation, (*b*) must remove refuse, filth, etc., from his premises in a properly covered cart, and must sweep up any spillings.

2. Collections of filth must not be placed near any streets or dwellings for longer than a specified time.

3. Filth placed for disposal on land within (?) yards of a street or building must be ploughed in or covered over (so as not to become a nuisance).

WATER SUPPLY

P.H.A., 1875.—A "contributory place" in a rural district includes those parishes, or parts of parishes, for which some public works, *e. g.* water-works, have been carried out, and which are liable to a special rate in consequence.

1. Any urban S.A. may construct or hire works or contract for the supply of water for the whole or part of their district, and any rural S.A. for the whole or part of any contributory place therein. The same rights exist for laying mains as for sewers.

2. Such water must be pure, and may be at such pressure as will carry it to the top storey of the highest dwelling.

3. The S.A. cannot construct waterworks within the supply area of a company empowered by Parliament if such company can supply the water for all reasonable purposes for which it is required.

4. If a house has not a proper supply, and one can be furnished at a cost not exceeding the local rate, or not more than twopence a week, the S.A. must, on the report of the Surveyor, insist on the work being done.

5. All existing public pumps, cisterns, wells, etc., for the gratuitous supply of water are under the control of the S.A.

6. Wells, etc., public or private, used for drinking or domestic purposes, that are so polluted as to be injurious to health, may be, by order of a court of summary jurisdiction, closed temporarily or permanently, or the purposes for which they are used may be limited.

7. If complaint is made to the L.G.B., and the L.G.B. are satisfied that the S.A. have not provided their district with a suitable water supply when one can be obtained at reasonable cost, the L.G.B. may make an order limiting the time in which it shall be procured. If the S.A. fail to comply, the L.G.B. may appoint some person to perform the duty at the cost of the S.A.

P.H. (Water) A., 1878.—Applies to rural S.A.'s, but L.G.B. may confer any or all of its powers on urban S.A.'s.

1. Every rural S.A. must see that every occupied dwelling has, within a reasonable distance, an available supply of wholesome water.

2. In default, notice to provide within six months is sent to the owner. If owner does not comply, another notice is sent to provide within one month. At the end of these seven months the S A. may do the work and recover expenses.

3. Owner has right of appeal against the order on any of the following grounds—

(*a*) That the supply is not required.
(*b*) That the time allowed is too short.
(*c*) That a supply cannot be got at reasonable cost.
(*d*) That the S.A. should provide the supply or render the existing supply wholesome.

The S.A. cannot then proceed with the work till authorised by a court of summary jurisdiction or by the L.G.B.

4. No new or rebuilt house may be occupied till S.A. certify that there is a sufficient supply of wholesome water within reasonable distance.

5. S.A. must inspect periodically the condition of the water supply; power of entry granted.

P.H. (London) A., 1891.—1. Any occupied house without proper and sufficient water supply is a nuisance, and not fit for habitation.

2. No new or rebuilt house may be occupied till S.A. certify that it has a proper water supply.

3. A water company must give S.A. twenty-four hours' notice before cutting off water supply.

4. Every S.A. shall make bye-laws for securing cleanliness and freedom from pollution of cisterns, etc., for storing water for drinking purposes.

5. If a well, cistern, etc. (public or private), is, or is likely to be, so polluted as to be injurious to health, the S.A. may apply to a petty sessional court for an order to close it temporarily or permanently, or to limit the purposes for which the water may be used.

POLLUTION OF WATER

(Rivers Pollution Prevention Act, 1876.)

Definitions.—"Stream" includes the sea to such extent, and tidal waters to such point, as may, after local inquiry and on sanitary grounds, be determined by the L.G.B.

"**Solid matter**" does not include suspended particles.

"**Polluting**" does not include innocuous discoloration.

1. No **solid refuse** likely to interfere with the flow or cause pollution may be discharged into a stream.

2. No solid or liquid **sewage** may be discharged into a stream. Where sewage was actually being discharged, or arrangements were being made to so discharge it, at the time of the passing of the Act, offence cannot be proved if every practicable means is being taken to purify the sewage. The S.A. do not need the consent of the L.G.B. before instituting proceedings in respect of solid refuse or sewage, and complaint of the nuisance may be made by one or more private individuals.

3. No polluting **liquid from a factory** or **solid matter from a mine** may be passed into a stream.

Proceedings may be taken only by a S.A. with the consent of the L.G.B. The L.G.B., on appeal, may order a defaulting S.A. to act. In a manufacturing district the L.G.B. may give consent to proceedings only when satisfied after inquiry that reasonably practicable means exist for rendering harmless such noxious fluids, etc., and that no injury will be inflicted on the industry by the proceedings.

4. S.A.'s must allow manufacturies to discharge liquids into the sewers, provided they do not injure the sewers, have too high a temperature, or interfere with the treatment of the sewage.

P.H.A., 1875.—1. No washings, etc., from gas-works may be run into any stream, reservoir, etc. Penalty of £200 and daily fine of £20.

2. With the consent of the Attorney-General the S.A. may take proceedings to prevent pollution of a watercourse by sewage.

P.H.A. (A.) A., 1890 (adoptive).—Penalty of forty shillings for throwing into a watercourse any cinders, ashes, bricks, stones, rubbish, dust, etc., likely to cause annoyance.

FOOD

Unsound Food

P.H.A., 1875.—1. (Sec. 116). Any M.O.H. or I.N. may at all reasonable times inspect any animal, carcase, meat, poultry, game, fish, flesh, fruit, vegetables, corn, bread, flour, or milk exposed or deposited for sale or for preparation for sale, and intended for the food of man. (Many important articles of food are not mentioned in the Act, nor can articles already sold be seized.)

M.O.H. or I.N. may seize any such unsound food and lay it before a justice. Any one obstructing is liable to a penalty.

2. If the justice is satisfied that the food is unsound, he shall condemn it and order it to be destroyed or so disposed of that it cannot be sold. Fine not exceeding £20 for every such article exposed or three months' imprisonment without option.

3. On application, a justice may grant a M.O.H. or I.N. a warrant to enter any premises for the purpose of searching for and seizing any unsound food as specified above. Twenty pounds penalty for obstruction.

P.H.A. (A.) A., 1890 (adoptive).—Extends P.H.A., 1875: "All articles intended for the food of man, sold or exposed for sale." A justice may order any such article to be destroyed although it has not been seized as directed in the P.H.A., 1875. If the convicted person is the occupier of a licensed slaughter-house, his licence may be cancelled.

Sale of Horseflesh Regulation Act, 1889.—" Horseflesh " includes the flesh of horses, asses, and mules, alone or mixed with any other substance.

1. Horseflesh may be sold only in a shop or place over which is conspicuously and legibly printed, in letters 4 inches long, a notice indicating that horseflesh is sold there.

2. If meat other than horseflesh is demanded, horseflesh shall not be supplied.

3. There is right of examination and seizure, and search warrants may be obtained from a justice as under P.H.A., 1875.

P.H. (Regulations as to Food) Act, 1907.—Under this Act the L.G.B. may make regulations for the prevention of danger to health from the importation, preparation, storage and distribution of articles of food and drink (other than drugs or water) intended for sale for human consumption, and such regulations may provide for the examination and taking of samples.

The following three sets of regulations have been made [1]—

I. **Public Health (Foreign Meat) Regulations, 1908** (applying mainly to Port S.A.'s, and directed against the importation of diseased meat).

"**Foreign**" means elsewhere than the United Kingdom, Channel Isles or Isle of Man.

"**Official Certificate**" means a label, stamp, etc., which has been published in the " London Gazette " as evidence that the meat has been certified, by a competent authority in the place of origin, to be free from disease, and to have been properly packed.

"**Importer**" means any person in the United Kingdom who, either as owner or consignee, agent or broker, is entitled to the possession, custody, or control of any foreign meat.

(*a*) **Foreign Meat, Class I,** includes scrap meat (without bone in its natural state of attachment and of such shape that the part of the carcase from which it comes cannot be identified), tripe and portions of pig carcases (other than bacon or ham) which have not an official certificate.

(*b*) **Foreign Meat, Class II,** means the whole carcases of pigs (not bacon or ham) which have not the head attached naturally, and are without the lymphatic glands in their natural position.

(*c*) **Foreign Meat, Class III,** means portions of the carcase of a pig (other than bacon or ham) which are accompanied by an official certificate.

(*d*) **Foreign Meat unclassed** means all other foreign meat.

1. The Customs officer, in the case of Class I and Class II meat, must give written notice to the master of the ship or the importer that the meat is not to be removed from the ship or landing-place till examined by the M.O.H. He must at the same time inform the M.O.H. In the case of Class III or unclassed meat the

[1] Also shell-fish regulations, 1915. See p. 109.

Customs officer may pass it or, if he thinks fit, detain it by written notice as in the case of Class I and II.

2. The M.O.H. must examine the meat at once. (*a*) If he decides it is fit for removal to a destination in England and Wales he makes out a *certificate* in duplicate, one copy being given to the Customs officer, and the other to the importer; (*b*) if he decides it should not be so removed he makes out a *notice* in triplicate, one going to the Customs officer, one to the importer, and one to the S.A. All notices and certificates must describe the foreign meat in such manner as will suffice to identify the particular consignment.

The M.O.H. may still deal within his district with foreign meat that has been allowed to be removed by the Customs officer.

3. The S.A., within twelve hours of receipt of a notice from the M.O.H., must send written notice to the Importer that the meat will be destroyed, unless he undertakes to export it at his own cost, or prove before a justice that the meat is not intended for sale for human consumption.

II. **Public Health (First Series: Unsound Food) Regulations, 1908.**

1. M.O.H. may examine any article of food before, or after, being landed. All facilities to be granted by shipmasters, etc., and if necessary a search warrant may be got from a justice. M.O.H. may seize any unsound food or give written notice that any article is not to be removed without permission or till after a justice's examination.

2. The justice must order the article, if unsound and intended for human consumption, to be destroyed, but not if it is impossible to prove it was intended for human consumption, in which case an order dismissing the complaint is made. Such order must contain a full description of the meat concerned, and a copy of it must be sent to the S.A.

3. A detailed record of each article destroyed must be kept by the S.A. for not less than one year.

4. **Samples** may be taken by the M.O.H., and forty-eight hours must be allowed for their examination. Longer periods may be arranged, but only with the consent of the Importer.

III. **The Public Health (Milk and Cream) Regulations, 1912.**

Preservative means any substance capable of retarding or neutralising sourness in milk or cream.

Thickening substance means sucrate of lime, gelatine, starch paste, or any other substance added to thicken cream; neither cane nor beet sugar is to be regarded as a preservative or thickening substance.

Preserved Cream means cream containing 35% or more, by weight, of milk fat to which has been added—

1. Boric acid or a mixture of borax and boric acid, or
2. H_2O_2 not exceeding 0·1% by weight.

Milk includes separated, skimmed, condensed, and dried milk.

1. No preservative may be added to milk intended for sale for human consumption.

2. No thickening substance may be added to cream or preserved cream.

3. No preservative may be added to cream containing less than 35% by weight of milk fat.

4. To cream containing more than 35% by weight of milk fat may be added, (*a*) boric acid, borax or a mixture of these, or (*b*) H_2O_2 not exceeding 0·1% by weight.

5. Sellers of preserved cream for human consumption must, in price-lists, etc., describe it as *Preserved Cream* (*boric acid*) or (*peroxide*), as the case may be.

6. Receptacles in which cream is sold or despatched to customers must be labelled "*Preserved Cream containing Boric Acid not exceeding ? per cent.*," or "*Preserved Cream* (*Peroxide*)."

7. In restaurants a large legible notice must be hung stating that the cream sold is preserved. An intimation on the bill of fare is sufficient. There is no need then to label the pots containing the cream.

8. The local S.A. enforce these regulations and take samples, etc., as under the S.F.D.A., 1875.

9. Importation into England and Wales of any foreign milk or cream not in accordance with these regulations is forbidden.

N.B.—Under the P.H. (Milk and Cream) Regulations, 1912, Amendment Order, 1917, not more than 0·4% boric acid may be added to cream. Cream preserved with boric acid or peroxide must in addition be labelled "Not suitable for infants or invalids."

The Sale of Food and Drugs

S.F.D.A.'s, 1875, 1879, and 1899.—"Food" includes every article used for food or drink by man, other than drugs or water, and any article which ordinarily enters into, or is used in the composition or preparation of, human food. It also includes condiments and flavouring matters.

"**Drugs**" include medicine for internal or external use.

"**Margarine cheese**" means any substance, compound or otherwise, prepared in imitation of cheese, and containing fat other than milk fat.

"**Cheese**" means the substance usually known as cheese, and containing no fat other than milk fat.

1. No article of food intended for sale shall be mixed, stained, coloured, or powdered so as to render it injurious to health, nor any drug (save for the purpose of compounding) so as to affect injuriously its quality or potency, if the same is to be sold. Penalty £50, but person charged cannot be convicted if he proves he was unaware, and could not reasonably have been aware, of the adulteration.

2. No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded. (1879 Amendment Act—Articles bought for analysis are sold to the prejudice of the purchaser, and articles need not be defective in all three respects, viz. nature, quality, and substance.)

Penalty £20, but no offence is proved—

(*a*) When matter not injurious to health has been added to a food or drug in its preparation as an article of commerce, and not fraudulently to increase bulk or weight or to conceal inferior quality.
(*b*) When patent foods and drugs are supplied in accordance with the specification of the patent.
(*c*) When the food or drug is unavoidably mixed with foreign matter during collection or preparation.
(*d*) When the food or drug is compounded as mentioned in this Act.

3. No person shall sell any compound article of food or drug not composed of ingredients as asked for. A label stating that the article is a mixture protects the vendor, provided the addition is not merely to increase weight, etc., or to conceal inferior quality.

4. Nothing may be abstracted from any food so as to injure its quality, substance, or nature. If the abstraction is declared at the time of sale no offence can be proved.

5. **Public Analysts** must be appointed, who must possess proper qualifications, must analyse any sample of food or drug on payment of 10*s*. 6*d*. per sample, and must render their reports on a special certificate. This certificate is taken as evidence in court, unless defendant requires analyst to attend in person. The analyst must render to the S.A. a quarterly summary of work done and the fees due, and the S.A. must send the report yearly to the L.G.B.

6. **Taking of Samples.**—M.O.H., Sanitary Inspector, Inspector of Weights and Measures, Inspector of Markets, or Police Constable may purchase samples for analysis, if directed to do so by the S.A., or if he suspects the food or drug to have been sold contrary to this act. Refusal to sell when payment is tendered incurs a penalty of £10. The officer must notify the vendor that the purchase has been made for the purpose of analysis by the Public Analyst. The sample must be divided into three parts, each labelled and sealed, and, if request is made, one part must be left with the vendor. A second part is retained by the purchaser for production in court if necessary, and the third is sent to the Public Analyst. (It is usual to offer the vendor one part.) The court may order the part retained by the purchaser to be sent to the Government Analyst in case of doubt.

7. Any person obstructing an inspector, or trying to bribe him, is liable to a fine of £20 for a first offence, £50 for a second, and £100 for any subsequent. Hard labour up to three months may be given in bad cases.

8. No proceedings may be taken after twenty-eight days from date of purchase (day of purchase not included). The summons must state particulars of the offence, with the name of the prosecutor, must not be made returnable in less than fourteen days from day of service, and must be accompanied by a copy of the analyst's certificate.

(Proceedings may be taken by the person taking the sample, *e. g.* the M.O.H.; this saves much time.)

9. If the defendant proves he sold the article as he got it, and under a written warranty, no conviction can follow.

Warranty or Invoice.—To be a legal defence, a copy of it must be sent to the purchaser within seven days from the service of the summons, along with a written notice that the defendant is to rely on it in his defence. The name and address of the Warrantor must be given, and he also must be informed, and may appear to give evidence. A warranty from outside the United Kingdom is no defence unless the purchaser can prove he has taken steps to verify the statements in it. A warranty to a master covers the servant.

On discharge of defendant on a warranty, proceedings may be taken against the warrantor, either in the district where the article was purchased or where the warranty was given.

Penalty for false warranty £20.

N.B.—So far the 1875 Act has been given with the necessary modifications of the later Acts. The following provisions are found entirely in the 1879 or the 1899 Act.

10. Whisky, brandy, and rum may be 25° under proof, gin 35°.

11. Samples of any article of food may be taken (not purchased) in the course of delivery (*e. g.* at a railway station), but, with the exception of milk, no sample may be taken unless with the consent, or at the request, of the purchaser or consignee.

12. Any one selling milk or cream in a public place must have his name and address clearly marked on the vehicles or cans.

13. Forbids **importation** of the following unless clearly labelled as such—margarine, margarine-cheese, adulterated or impoverished milk or cream, separated or skimmed condensed milk, or any other adulterated or impoverished article of food to which His Majesty may by Order in Council direct this section of the Act to apply.

Penalties, first offence £20, second £50, subsequent £100.

Proceedings are to be taken by the **Commissioners of Customs,** who shall take any necessary samples, divide such into three parts, sending one to the importer, another to the Government Laboratories, and retaining the third. When an offence has

been committed, the Commissioners of Customs must notify the Board of Agriculture of the name of the importer and the place of consignment.

An article of food is adulterated or impoverished if any other substance has been mixed with it, or any part abstracted, so as to affect injuriously its quality, substance or nature.

14. The **L.G.B.,** in the interests of the consumer, and the **Board of Agriculture,** in the interests of agriculture, may instruct their own officers to take samples. Such samples must be divided into four parts, three are dealt with as ordinary samples under the S.F.D.A., 1875, and the fourth is sent to the Board concerned. The analyst's fee is paid by the S.A. in whose district the sample was taken, and the S.A. must take all necessary legal proceedings.

15. The L.G.B. may act in default of any S.A. not carrying out all the duties imposed by these Acts, and the S.A. must pay all expenses.

16. Board of Agriculture may make regulations regarding the analysis of milk, cream, butter, and cheese, and fix standards for them. (Three sets of regulations have been made pp. 283–284.)

17. **Margarine and Margarine Cheese.**—Margarine cheese to be dealt with as margarine, and all packages containing it to be clearly branded with the name (a label attached is not sufficient). When sold retail it must be wrapped in a paper printed with the word Margarine or Margarine Cheese in ½-inch capital letters, and there must be no other printed matter on the paper.

Every manufacturer or wholesale dealer in margarine, or margarine cheese, must keep a register to show the quantity and destination of each consignment. The premises must also be registered with the S.A., who must notify the Board of Agriculture. Officers of the Board of Agriculture have right of entry to inspect the register, take samples, etc. Penalties for not keeping the register properly.

Unlawful to make, import, sell or expose for sale margarine the fat of which contains more than 10% butter fat.

Butter and Margarine Act, 1887

"**Butter**" means the substance made exclusively from cream or milk, or both, with or without salt or other preservative or colouring matter.

1. An employer, charged under this Act, may bring into court the person really guilty, *e. g.* shop assistant, who shall be convicted, provided the employer can prove that he took all precautions and warned the person against committing any offence.

2. Every package containing margarine shall be plainly marked, top, bottom and sides, with the word "Margarine" in capital letters, each not less than ¾ inch square. If exposed

for retail sale, each parcel of margarine must have attached to it a label with "Margarine" clearly visible in capital letters each at least 1½ inches square.

3. Any article not so labelled will be considered butter, and the vendor is liable unless he can show a written warranty or invoice stating that he bought the article as butter and could not have known it was anything else. Defendant must pay costs of prosecution unless he notifies prosecutor of his intention to use this warranty as a defence.

4. "Milk-blended" butter must be consigned under a name approved by the Board of Agriculture.

Most of the remaining provisions are incorporated in the S.F.D.A., 1899.

Butter and Margarine Act, 1907

"**Margarine**" is any article of food, whether mixed with butter or not, which resembles butter and is not "milk-blended" butter.

1. Extends the B. and M.A., 1887, as modified by S.F.D.A., 1899, regarding registration, to butter factories, and factories and wholesale establishments for milk-blended butter. Also registers of consignments of milk-blended butter must be kept.

2. No butter factory may communicate, other than by a public road, with any margarine factory or factory or wholesale establishment for milk-blended butter. (Provision made to exempt cases in being at the time of passing of the Act.)

3. Any officer of the Board of Agriculture or L.G.B. may enter such registered premises at reasonable times to inspect or take samples. Unregistered premises, if suspected, may be entered by an officer of the Board of Agriculture with special authority.

4. Penalty if any substance intended to be used as an adulterant of butter is found in a butter factory.

5. Limit of 16% moisture in butter and margarine and 24% in milk-blended butter.

6. Milk-blended butter must be dealt with under a name approved by the Board of Agriculture, and comes under all the conditions of sale of margarine. Further, the paper wrapper must have printed on it any description regarding the percentage of moisture as may be approved by the Board of Agriculture.

7. L.G.B. may make regulations limiting the use of preservatives in butter, margarine, and milk-blended butter. Contravention of these regulations constitutes an offence.

Sale of Milk Regulations (1901). (Made by Board of Agriculture under Sec. 4, S.F.D.A., 1899.)

1. Sample not genuine if it contains less than 3% of milk fat, or 8·5% of non-fatty solids, unless sold as skimmed, separated, or condensed milk.

Sale of Milk Regulations (1912).—Skimmed or separated milk must not contain less than 8·7% of non-fatty solids.

Sale of Butter Regulations (1902).—Butter must not contain more than 16% of moisture.

Milk

Under the Contagious Diseases (Animals) Acts, 1878 and 1886, powers were given first to the Privy Council, and later transferred to the L.G.B., to make orders concerning—

1. Registration with the S.A. of cowkeepers, dairymen, and purveyors of milk.
2. Inspection of cattle and sanitation of cowsheds, dairies, etc.
3. Cleanliness of premises and vessels.
4. Protection of milk from infection.
5. Authorisation of S.A.'s for making regulations.

D.C.M.O.'s 1885, 1886, 1899.—1. All persons carrying on the trade of cowkeeper, dairyman, or purveyor of milk must be registered.

(N.B.—The premises need not be registered, this is provided for in the 1915 Act.)

2. S.A. must keep a correct register, and advertise from time to time locally that registration is required, and prescribe the mode of registration.

3. Registration not necessary—
   1. For cowkeepers or dairymen who use all their milk for making butter or cheese, or both.
   2. For those who sell small quantities of their own cows' milk to workmen or neighbours.

4. No buildings, save those so used before June 30, 1885, may be occupied as a dairy or cowshed until the occupier satisfies the S.A. regarding lighting, ventilation, cubic space, cleansing, drainage and water supply, and has given the S.A. a month's notice.

5. No building may be used as a dairy or cowshed unless proper provisions exist for—
   (*a*) The health of the cattle.
   (*b*) The cleanliness of the milk vessels.
   (*c*) Protection of the milk against infection.

6. No person suffering from an infectious disorder, and no recent contact of such a case, may have anything to do with the production, distribution, or storage of milk.

7. No closet, privy, cesspool, or urinal may be within, communicate with, or ventilate into, any dairy or milkshop.

8. No milkshop may be used as a sleeping-place, or for any purpose likely to contaminate the milk.

9. No swine may be kept in any cowshed or milk store.

10. The S.A. may make regulations regarding—
   (*a*) Inspection of cattle in dairies.
   (*b*) Lighting, ventilation, cleansing, drainage, and water supply.
   (*c*) Cleanliness of premises and vessels.
   (*d*) Precautions to be taken against infection of the milk.

N.B.—Every regulation must be advertised locally, and a copy must be sent to the L.G.B. within a month of its coming into force. The L.G.B. may revoke any regulation if too restrictive, etc.

11. Milk of cattle suffering from cattle plague, pleuro-pneumonia, foot and mouth disease, or disease of the udder (if certified to be tubercular by a Veterinary Surgeon) shall not be (1) mixed with other milk, (2) sold or used for human food, or (3) sold or used for food of other animals unless boiled.

Model Regulations.—1. All assistance must be given to any authorised person to inspect.

2. If cows are grazed on grassland during the greater part of the year, or are turned out daily, the following conditions must be observed—

- (*a*) Sufficient lighting from the walls or roof, and adequate ventilation.
- (*b*) Interior of the cowshed to be cleansed in every part sufficiently often to keep it sweet, the roof and walls to be lime-washed inside at least twice a year (say, May and October).
- (*c*) Floor to be swept and dung removed at least once daily.
- (*d*) Liquids from the floor must drain in an open channel to some drain-inlet outside the cowshed. No drain-inlet allowed within the cowshed.
- (*e*) A suitable and sufficient supply of water must be maintained, and any receptacle for it must be cleansed when necessary. In the case of a storage cistern, it must be covered, ventilated, and accessible.

3. If cows are not so grazed out on grassland or turned out daily, all the foregoing conditions must apply, and, in addition, each cow must have 800 cubic feet of space—no height above 16 feet to be included.

4. Dairies must be properly lighted and ventilated, and kept sweet by sufficient cleansing. The floor must be cleansed with water at least once a day. Drainage and water supply as for cowsheds.

5. Milk vessels must be cleansed, as often as may be necessary, with steam or clean boiling water, and this must always be done after such vessels have been in use.

6. No milk intended for sale may be kept in any kitchen, living- or sleeping-room, in any room in which there is a direct drain-inlet, or which is liable to be contaminated with impure air or exhalation, or in any room in which there is or has been a person suffering from an infectious disease, until after proper disinfection.

7. Before milking, the udder and teats of cows must be

thoroughly cleansed, and the hands of the milker must be clean and free from all infection and contamination.

8. Penalties provided of £5 for offence, and 40*s.* for continuance.

Infectious Diseases Prevention Act, 1890 (adoptive).—Any M.O.H., if he believes that infectious disease in his own district is, or is likely to be, caused by milk from a dairy within or without his own district, may obtain from a justice of the district where the dairy is situated an order to inspect it, and, if accompanied by a Veterinary Surgeon, to inspect the animals. On the report of the M.O.H., the S.A. may give the dairyman twenty-four hours notice to appear, and show why an order prohibiting the sale of milk in their district should not be made. Notice of such order, if made, must be sent to the L.G.B., the C.C. and the S.A. of the district concerned.

Milk and Dairies (Consolidation) Act, 1915.[1]—Repeals C.D. (A.) A.'s, 1878 and 1886 and S.F.D.A., 1899, Secs. 9 and 11.

"**Dairy**" means any farm, cowshed, milk store, milk shop, or place where milk is sold, or any place used for manufacturing butter, cheese, dried milk, or condensed milk. Does not include a shop in which milk is sold only in the properly closed and unopened receptacles in which it was delivered to the shop, or any place where milk is sold for consumption on the premises only.

"**Milk**" includes cream, skimmed milk, and separated milk.

1. Orders regarding the following matters may be made by the L.G.B. (must be agreed to by the Board of Agriculture and submitted to both Houses of Parliament)—

(*a*) Registration with the S.A. of *dairies* and dairymen.
(*b*) Inspection of dairies, employees, and cattle.
(*c*) Lighting, ventilation, cleansing, drainage and water supply of dairies.
(*d*) Cleanliness of stores, milk shops, and vessels.
(*e*) Protection of milk from infection and contamination.
(*f*) Prohibition of sale of *dirty* or infected milk or milk products.
(*g*) Cooling, conveyance, and distribution of milk.
(*h*) Labelling, closing, and sealing of churns.
(*i*) Prohibiting the addition of colouring matter to, or any other form of adulteration of, milk.
(*j*) Conditions regarding the sale of "certified milk."
(*k*) Authorising S.A.'s to make regulations regarding the foregoing with the observance of any necessary conditions laid down by the L.G.B.

2. An order regarding inspection of cattle may require that a sample of milk be milked from any particular teat in the presence of the inspecting officer.

[1] A Bill is at present before Parliament to amend this Act. The Act itself is not yet in force (May 1920).

3. The M.O.H. of any County or County Borough, if he believes that tuberculosis is, or is likely to be, caused by milk from any dairy in his district, may proceed to stop the supply in the following manner—

(*a*) Report to his S.A. and enclose any veterinary or bacteriological reports he may have.
(*b*) Notice from the S.A. to the dairyman to appear before them (or explain in writing) within a fixed time, not less than forty-eight hours after service of the notice, to show cause why an order should not be made prohibiting him from supplying milk from his dairy, or any particular cow, for human consumption or for manufacture into products for human consumption. This notice must be accompanied by any reports made regarding the dairy, and the facts of the case must be reported to the L.G.B. and the Board of Agriculture.
(*c*) If authorised, the M.O.H. may withdraw an order.
(*d*) Dairyman may appeal to a court of summary jurisdiction—pending the hearing the order will remain in force unless withdrawn.

4. The M.O.H. of any S.A., if he believes that tuberculosis is, or is likely to be, caused by any milk sold in his own district, must ascertain the source of the supply, and notify the M.O.H. of the County or County Borough concerned, who must have the cattle in the dairy inspected. The complaining M.O.H. must have notice of such inspection, and may be present along with a Veterinary Surgeon appointed by his S.A. The dairyman, too, has the right to have a Veterinary Surgeon present. Copies of any bacteriological or veterinary reports, and a notice of any action taken, must be sent to the M.O.H. who made the complaint.

5. Samples of milk, in the manner provided for in the S.F.D.A.'s, may be taken in the course of delivery within the S.A.'s own district, and provision is made for taking of samples in other districts, *e. g.* the M.O.H. of X may, by notice in writing, require the M.O.H. of Y to take from a dairy in Y a sample of milk which is sold in X. Court proceedings may be taken either in X or Y.

6. No milk may be sold from a cow suffering from tuberculosis, acute mastitis, foot and mouth disease, anthrax, or actinomycosis of the udder, provided the vendor could reasonably have been aware that such disease existed.

7. Vehicles and vessels from which milk is sold in the streets must be clearly marked with the name and address of the vendor.

8. Receptacles for the sale of separated or skimmed condensed milk must be clearly labelled " Machine Skimmed," or " Skimmed Milk."

9. S.A.'s may, and if required by the L.G.B. shall, appoint or combine to appoint qualified Veterinary Surgeons.

10. With the approval of the L.G.B., a S.A. may establish and maintain milk depots, where milk specially prepared for infants under two years of age may be sold at not less than cost price.

11. A defaulting S.A. may be compelled to undertake its duties under this Act, and in the case of a District Council, the C.C. may take over the powers.

12. Penalties provided of not less than £5 in the first case with 40*s*. a day for continuance, and £50 for subsequent offences.

13. The Act to come into operation not less than one year after the termination of the Great War, as the L.G.B. may decide.

Tuberculosis Order, 1913,[1] issued by the Board of Agriculture.

1. A S.A. must investigate, with the assistance of a Veterinary Surgeon, any report received (*a*) of a cow suffering from T.B. udder or giving T.B. milk, and (*b*) of any bovine animal suffering from T.B. with emaciation, with a view to causing the slaughter of any such found within the district of the S.A.

2. The Veterinary Surgeon may take samples of milk, fæces, urine, and abnormal discharges, may apply the tuberculin test to a suspected animal if he gets written consent from the owner, and may examine any cattle in contact with a suspect.

3. Every person owning a cow or bovine animal affected as described above must notify a constable or inspector of the S.A.; Veterinary Surgeons must also notify cases occurring in their practice.

4. All such animals must be slaughtered and a post-mortem examination made.

5. The animal slaughtered is to be valued in its condition at the time of valuation.

6. Compensation is to be paid by the S.A. for all animals slaughtered.

(*a*) When T.B. is found, the amount of compensation depends on the extent of the disease. Thus in advanced T.B. (which would necessitate the whole carcase being condemned in accordance with the findings of the Royal Commission of 1898) a quarter of the value or 30*s*., whichever sum is greater, is paid after deducting half the cost of valuation. In cases where the whole carcase would not be condemned compensation, to an extent of three-quarters the value, is paid after deducting one-half the cost of valuation.

(*b*) If post-mortem examination shows no T.B., compensation to the full value of the animal, plus 20*s*., is paid.

7. Premises occupied by any such T.B. animal must be thoroughly cleansed and disinfected.

[1] Operation suspended during the War.

8. Certain precautions must be adopted regarding the isolation of suspected animals and the treatment of the milk.

9. For the first five years after the commencement of this order, half the money spent in compensation by S.A.'s was to be refunded by the Treasury.

STREETS, BUILDINGS, DWELLINGS, etc.

P.H.A., 1875.—1. All public streets belong to, and must be maintained by, urban S.A.'s.

2. Urban S.A.'s may compel owners of premises in private streets to carry out any necessary works regarding sewerage, levelling, paving, etc.

3. (Sect. 157) Urban S.A.'s may make bye-laws regarding :—

(*a*) Requirements of new streets.
(*b*) Structure of buildings for securing stability, prevention of fire, and protection of health.
(*c*) Provision of space around buildings for purposes of ventilation.
(*d*) Drainage of buildings, etc. (already noted, see p. 272).

4. New buildings include those—

(*a*) Re-erected after being pulled down to, or below, the ground floor.
(*b*) Not originally intended as human habitations, but subsequently so converted.
(*c*) Originally constructed as one dwelling-house, but subsequently converted into more than one.

P.H.A. (A.) A., 1890 (adoptive).—1. Urban S.A.'s may make additional bye-laws regarding—

(*a*) Sufficient water for flushing water-closets.
(*b*) Floors, hearths, staircases, and height of rooms in human habitations.
(*c*) Paving of yards.
(*d*) Secondary means of access for removal of house refuse.

2. Rural S.A.'s may make bye-laws regarding the matters mentioned in sub-sections (*a*) and (*b*) noted above, and also in Sect. 157 of the P.H.A., 1875, sub-sections (*b*), (*c*), and (*d*) as shown above.

3. No dwelling-room or work-room may extend in any of its parts over a privy, midden, or ashpit.

4. No new building may be erected on ground filled up with organic matter, until such has been rendered innocuous.

P.H.A. (A.) A., 1907 (adoptive).—New buildings include those—

(*a*) Re-erected after being pulled, or burnt, down to within 10 feet of the ground, or so as to leave only the framework of the lowest storey.

(*b*) Added to by the raising of a roof, the altering of a wall, the making of any projection, or the roofing of an open space between walls or buildings.

Model Bye-laws (under 157 P.H.A., 1875).—Not applicable to most public buildings, or to others such as outhouses, if situated at least 10 feet from any other building and not heated otherwise than by hot water.

New Streets.—A carriage road to be at least 36 feet wide, if over 100 feet long; if less than 100 feet long, and not to be used as a carriage way, it must be at least 24 feet wide, and there must be an opening at one end as wide as the street.

Walls, Foundations, etc.—1. Site of every domestic building must be asphalted or covered with 6 inches of concrete, and should not be on "made ground." It must be under-drained where necessary.

2. Walls must be made of good incombustible material properly bonded, resting on proper footings.

3. Every wall must have a damp-proof course of sheet lead, asphalt, slates in cement, or other impervious material below the level of the lowest timbers, and at least 6 inches above the ground.

4. External walls must be at least 9 inches thick—more for high buildings.

5. Party walls must be carried at least 15 inches above the roof.

6. Roofs must be covered with tiles or other incombustible material.

Open Space Round Buildings.—1. There must be at least 24 feet in front of any part of a domestic building—measured to the boundary of any land or premises opposite.

2. Behind there must be not less than 150 square feet of space, and in no part must the distance from the house to the boundary wall at the back be less than 10 feet. This space must be free from any erection above ground save a water-closet, earth-closet, or privy, and an ashpit. If the height of the building is 15, 25, or 35 feet or over, this space must be 15, 20, or 25 feet across.

Ventilation.—1. Every room on the lowest storey must have a boarded floor with at least 3 inches clear space between this and the covering of the site. This space must be ventilated by air-bricks, etc.

2. In every habitable room there must be at least one window opening directly into the external air. The area of the window or windows, clear of the frames, must equal at least one-tenth of the floor area. One-half of the window must open, and the opening must extend to the top.

3. Every habitable room without a fireplace and flue must have a special ventilation opening at least 100 square inches in size.

Paving of Yards, etc.—Yards and open spaces connected with dwelling-houses must be paved with impervious bricks, etc., and all waste water must be carried off.

COMMON LODGING-HOUSES

A common lodging-house is one "in which persons of the poorer classes are received for short periods, and, though strangers to one another, are allowed to inhabit a common room. It does not include hotels, inns, etc., let to the upper and middle classes."

P.H.A., 1875.—1. Every S.A. must keep a register of C.L.H.'s, containing names and addresses of keepers, situation of houses, and number of lodgers authorised.

2. Every C.L.H., if inspected and approved by the S.A., must be registered.

3. Before registration the keeper must produce a certificate of character signed by three local householders.

4. When so ordered by the S.A. the keeper must conspicuously fix the words "Registered Common Lodging-House" outside the premises.

5. Every S.A. *must* make bye-laws regarding (1) the number of lodgers allowed and separation of the sexes, (2) cleanliness and ventilation, (3) procedure when a case of infectious disease occurs, and (4) the well-ordering of C.L.H.'s.

6. Sufficient water supply must be laid on.

7. Walls and ceilings must be lime-washed twice yearly, in the first weeks of April and October.

8. Any keeper receiving beggars and vagrants may be required to send a daily return to the S.A. of all persons using the C.L.H. during the preceding day and night.

9. The M.O.H. and the Relieving Officer must be notified of any case of infectious disease.

P.H.A. (A.) A., 1907 (adoptive).—1. Registration of keepers to be only for a year or less, but renewable.

2. Either the keeper or his registered deputy must remain on the premises between 9 p.m. and 6 a.m.

3. Sufficient and suitable sanitary conveniences to be provided for each sex, etc. In default the S.A. may do the work and recover expenses.

Memorandum of L.G.B. provides for the proper structure and fittings of C.L.H.'s. In addition it lays down—

1. Three hundred cubic feet of space per head.

2. House to possess kitchen and day-room apart from bedrooms.

3. If constant water supply not laid on, at least 10 gallons of water per head per day must be provided where there are water-closets and 5 gallons where there are dry-closets.

4. A separate closet should be allowed for every twenty registered lodgers.

5. Washing accommodation, where possible, should be in a special place, and there should be proper lavatory basins with taps and discharge pipes.

Model Bye-laws (under Sec. 80 of P.H.A., 1875).—1. S.A. must specify the maximum number of lodgers for each room, and a notice showing the number allowed must be hung conspicuously in the room.

2. No person over ten to sleep in a room occupied by persons of the opposite sex.

3. Rooms may be reserved for married couples, but each bed must be sufficiently screened off.

4. Yards, etc., to be kept clean; all floors to be swept daily before 10 a.m. and washed at least once weekly. All fittings to be kept clean.

5. All solid and liquid filth to be removed from rooms before 10 a.m. each day.

6. All closets and ashpits to be kept clean and in good order.

7. All windows of sleeping-rooms to be kept fully open at least one hour in the forenoon and one hour in the afternoon, except in bad weather, or when a room is occupied by a sick person.

8. Sufficient wash-basins and towels must be provided.

9. Bedclothes and bedding must be cleansed as often as necessary, and bedclothes must be removed as soon as possible after the bed has been vacated and, with the bed, must be exposed to the air for one hour daily. No bed may be occupied within eight hours after being vacated, and no bed may be occupied by more than one male person over the age of ten.

10. In the event of a case of infectious disease occurring, all necessary precautions must be taken. Only the wife of the lodger or other relative or attendant may occupy the same room. The M.O.H. may limit the number of lodgers permitted, and he must be notified of the death, removal, or recovery of any patient. Thorough disinfection must be practised, and the room cannot be re-let till two days after notice has been sent to the M.O.H. that everything has been cleansed.

11. Copies of the bye-laws must be conspicuously placed in the house or rooms.

HOUSES LET IN LODGINGS

P.H.A., 1875, Sec. 90 (as amended by H.W.C.A.).—Any S.A. may make bye-laws regarding houses let in lodgings—

1. For fixing the number of occupants and separation of the sexes.

2. For registration and inspection.

3. For enforcing drainage, closet accommodation, lime-washing, cleanliness, and ventilation, etc.

4. For giving notice of, and taking precautions against, infectious disease.

H.T.P.A., 1909.—The bye-laws should impose on the owner (and not on the lodger) any duty involving the execution of works. In default, the S.A. may do the work and recover expenses.

Model Bye-Laws[1]

"**Lodging-house**" means a house which is let in lodgings, or occupied by members of more than one family.

Houses exempted—when the rent, inclusive, and exclusive of any rent for furniture, exceeds sums fixed by the S.A.

1. Three hundred cubic feet of space for each person in sleeping-rooms, and 400 in rooms used both for living and sleeping. Half these amounts for children under ten.
2. After written notice, all information necessary for registration must be sent to the S.A.
3. Free access to be given for inspection.
4. One closet for every twelve persons.
5. If two or more lodgers have the use of any cistern, court, staircase, passage, closet, or ashpit, the duty of cleansing it falls on the landlord, who must also keep in good order all drains and closets.
6. Floors to be swept by lodgers once a day, and washed once a week, all room fittings to be kept clean, and all solid and liquid filth to be removed from the room at least once daily.
7. No animals may be kept in such a way as to render the premises unhealthy.
8. Landlord must lime-wash all walls and ceilings and cleanse the whole premises once every year in the first week of any specified month.
9. Courtyards must be properly paved and drained.
10. All windows of sleeping-rooms must be kept fully open for one hour in the forenoon and one hour in the afternoon of each day, except in bad weather and in the case of a sick-room.
11. Landlord must notify M.O.H. of any case of infectious disease, whenever he becomes aware of it.
12. A lodger must notify the landlord and the M.O.H. if a case of infectious disease occurs in his rooms.
13. If the sick person is ordered to hospital, the landlord and the lodger must assist in this, and follow out any instructions given by the M.O.H.

In accordance with the meaning of H.T.P.A., 1909, the landlord is now looked on as the owner, and duties regarding

[1] Under the H.T.P.A., 1919, a new set of Bye-laws has been issued regarding the matters mentioned on p. 301.

structural repairs and such-like fall on him. Any one hiring the premises and sub-letting them to lodgers is known as the tenant, and many of the duties, formerly assigned to the landlord, fall on him.

UNDERGROUND (CELLAR) DWELLINGS

P.H.A., 1875.—1. No underground room, built or rebuilt after the passing of the Act, may be occupied *separately* as a dwelling. Any cellar in which a person passes the night is considered to be occupied as a dwelling.

2. No underground room may be let, or occupied, separately unless it meets with the following requirements—

(*a*) Height in every part at least 7 feet, 3 feet of the height being above the level of the adjoining ground.
(*b*) An area, at least 2½ feet wide and 6 inches below the floor level, extending along the whole frontage. Steps to the area, etc., must not be opposite the window.
(*c*) Effectual drainage, and drain at least 1 foot below floor level.
(*d*) Use of closet and ashpit.
(*e*) Fireplace and chimney; external window made to open and at least 9 square feet clear of the frame. A window 4 square feet is required for a back cellar let along with a front one.

3. If two convictions within 3 months, the cellar may be closed temporarily or permanently.

P.H. (Lond.) A., 1891.—The following additions or alterations are found—

1. The area must be at least 4 feet wide and paved, and outer walls must have a damp-proof course.
2. Drains under the room must be gas-tight.
3. Windows must be one-tenth of the floor area clear of the frames, and one-half of each must open to the top.

H.T.P.A., 1909.—Closing orders may be made in respect of cellars used habitually as sleeping places, which are not on an average 7 feet high, and which do not conform with regulations made by the S.A. with the consent of the L.G.B., regarding ventilation, lighting, and protection from damp and effluvia. The cellar is then closed only as a sleeping-room.

TENTS AND VANS

H.W.C.A., 1885 (Sec. 9).—1. Any inhabited tent, van, shed, or structure, in such a state or so overcrowded as to be a nuisance or injurious to health, comes under Sec. 91 of the P.H.A., 1875.

2. A S.A. may make bye-laws regarding them.

3. Any person authorised by the S.A. or a J.P. may enter and examine for the existence of a nuisance or a case of infectious disease.

Model Bye-laws contain special clauses for dealing with infectious diseases, enabling the M.O.H. to restrict the movements of tent- or van-dwellers, and to secure disinfection. Water supplies are protected against contamination by such persons.

CANAL BOATS

(Canal Boats Acts, 1877 and 1884)

"**Canal**" includes any river, lake, or inland water, whether it is, or is not, within the ebb and flow of the tide.

"**Canal Boat**" means any vessel, however propelled, used to convey goods along a canal, and not a ship registered under the Merchant Shipping Act, unless L.G.B. order otherwise.

1. Only registered canal boats can be used as dwellings, and then only by the number of persons of the age and sex specified.

2. L.G.B. shall make regulations (1) for registration, (2) for marking, lettering, and numbering, (3) for fixing the number, sex, and age of persons allowed to occupy a boat, (4) for cleanliness and prevention of disease.

3. The registration authority is one or more S.A.'s whose districts abut on the canal on which the boat plies. The boat must be registered as belonging to some place which is a school district.

4. On registration two certificates are given, stating the owner's name and the number of the boat, the place to which it belongs, and the number, age, and sex of the persons allowed to dwell in it. The owner keeps one certificate, and the master the other. Every boat must have marked on both sides or on the stern its number, its place of registration, and the word "registered."

5. Boats may be detained for disinfection in the case of infectious disease, and all necessary precautions must be taken.

6. Power of entry to inspect, etc.

Regulations of the L.G.B.—1. One or more clean, dry cabins—after-cabin not less than 180 cubic feet, fore-cabin 80 cubic feet, of free air space, if used as dwellings.

2. Some means of ventilation other than the door, sufficient sleeping accommodation, and one cabin must contain a stove and chimney.

3. Storage for at least 3 gallons of water.

4. If the usual cargo is offensive, there must be a double water-tight bulkhead between an inhabited cabin and the hold, with an interspace of 4 inches open to the air and provided with a pump.

5. At least 60 cubic feet of space for every person over twelve

years, and not less than 40 cubic feet below twelve. In "fly boats" worked by shifts, cabins occupied at the same time by two persons over twelve must have a cubic capacity of at least 180 feet.

6. Males over fourteen and females over twelve must not sleep in a cabin with a married couple, nor may they share the same cabin unless married.

7. Cabin to be painted every three years, and kept clean.

8. Bilge water to be pumped out daily.

9. Master to notify any case of infectious disease (1) to the S.A. of the district through which he is passing, (2) to the S.A. of the place of destination, and (3) to the owner, who in turn must notify the S.A. of the place to which the boat belongs.

10. After detention for disinfection, the master must be given a certificate by the S.A. that the boat is free from infection, and he cannot proceed till this is done.

HOUSING OF THE WORKING CLASSES ACT, 1890

Part I

Unhealthy Areas (not applicable to Rural Districts)

1. The M.O.H. may on his own initiative, or must on the complaint of two J.P.'s or twelve ratepayers, report in writing to his S.A. regarding the unhealthiness of an area. This is known as an "official representation." If, however, the M.O.H. does not make such representation, or if his report does not satisfy the complainers, they may appeal to the L.G.B., who may appoint a legally qualified medical practitioner to inspect and report. If he declares the area unhealthy, his report is sent by the L.G.B. to the S.A., who must proceed as though the report had come from their own M.O.H.

2. The S.A. may resolve that the area is unhealthy, and must then proceed to make an improvement scheme, if satisfied on such representation, (*a*) that any houses, courts, or alleys are unfit for human habitation, or (*b*) that the closeness or bad condition of streets or houses, or want of light or ventilation, or any sanitary defects, are injurious to the health of persons dwelling in the buildings of the area or in neighbouring buildings, and that such a state of affairs can be dealt with most satisfactorily by an improvement scheme.

3. If the S.A. fail or refuse to act, the L.G.B. may order a local inquiry to be held.

4. The scheme may provide for opening out the area, but must provide for proper sanitary arrangements, and also for dwelling accommodation for the working-classes displaced by the scheme (outside London only if the L.G.B. so direct).

5. Notices must be served on all affected persons, and the scheme must be advertised according to the Act.

6. Application must be made to the L.G.B. for a Provisional Order confirming the scheme, which is granted only after a local inquiry.

7. Final confirmation by Act of Parliament.

N.B.—The whole procedure is complicated and costly, and has not found favour with S.A.'s.

Part II

Unhealthy Dwelling-houses

"**The owner**" includes lessees and mortgagees of any premises requiring to be dealt with, save those entitled to receive rent under a lease the original term of which is less than twenty-one years.

1. The M.O.H. must report to the S.A. any dwelling-house, or houses, that appears to be so injurious to health as to be unfit for human habitation.

2. Four householders living near by may complain to the M.O.H. regarding such houses, and he must then report to his S.A. As before, these householders may appeal to the L.G.B. if the S.A. fail to act.

3. If satisfied that the house is unfit for human occupation the S.A. may summon the owner before a court of summary jurisdiction and apply for a Closing Order (under P.H.A., 1875) against the owner (to prevent the premises being used for human habitation).

4. Where nothing has been done by the owner to render the premises fit during the operation of the Closing Order, the S.A. may resolve to demolish the building, and serve a Demolition Order on the owner. An appeal to a court of quarter sessions is allowed. The S.A. themselves may, in default, demolish the building and recover expenses, any surplus being given to the owner.

N.B.—After demolition, no building likely to be injurious to health may be erected on the site.

Obstructive Buildings.—1. The M.O.H., or four inhabitant householders, may complain in writing to the S.A. of any building which, though it may not be unfit for human habitation, yet stops proper ventilation of another building or prevents the carrying out of measures for remedying some nuisance injurious to health in another building.

2. The S.A. may then resolve to demolish such obstructive building. Appeal to quarter sessions is allowed.

3. The S.A. may purchase the site and preserve the whole or part of it as an open space.

4. Rural S.A.'s must send to the C.C. copies of all Closing Orders and all representations made to them with regard to obstructive houses, or houses unfit for human habitation. A

county M.O.H. may make representations regarding unhealthy dwellings, etc., to his C.C., who may forward such to the Rural District Council concerned.

Reconstruction Schemes (for small areas).—The S.A. may make reconstruction schemes for areas too small to be dealt with under Part I. The procedure is simpler than in Part I. A local inquiry by the L.G.B. must be held, and a Provisional Order made. If the scheme is unopposed confirmation by Parliament is not required.

Part III

Working-class Lodging-houses.—Such include separate houses or cottages for one or more families. "Cottages" may include a garden of not more than one acre.

This part of the Act may be adopted with the consent of the L.G.B. in the case of urban S.A.'s, and of the C.C. in the case of rural S.A.'s (no longer adoptive since H.T.P.A., 1909).

S.A.'s may erect, lease, or purchase lodging-houses, and may acquire land for this purpose. They may make bye-laws for their management.

By a later Act (1900) S.A.'s may establish or acquire lodging-houses outside their own districts.

HOUSING, TOWN PLANNING, ETC., ACT, 1909

Part I

1. Part III of the H.W.C.A., 1890, ceases to be adoptive, and takes effect in all urban and rural districts.

2. If the S.A. have failed in their duties under Parts II or III of the H.W.C.A., 1890, and complaint is made to the L.G.B., the L.G.B. must hold a local inquiry and, if satisfied, order the defaulting S.A. to proceed. Such order of the L.G.B. must be laid before both Houses of Parliament, and may be enforced by mandamus.

Complaint may be made—

- (*a*) In the case of a rural district, by the C.C., Parish Council, or four householders.
- (*b*) In the case of an urban district of a county, by the C.C. or four householders.
- (*c*) In the case of any other S.A., by four householders.

3. (*a*) Provided that houses at the following maximum rentals are not let on a non-breakable, repairing lease of not less than three years, any contract to let implies that, at the beginning of the lease, the house is reasonably fit for habitation — maximum rentals: London, £40; boroughs and urban districts of over 50,000 population, £26; elsewhere, £16.

(*b*) During the lease, the landlord must keep the house reasonably fit for habitation.

(*c*) The landlord or S.A. may, after twenty-four hours' written notice to the tenant, enter and inspect such house.

(*d*) If the house is not reasonably fit for habitation, the S.A. must in writing require the landlord to do what is necessary.

(*e*) Within twenty-one days of receipt of this notice, the landlord may notify the S.A. that he intends to close the premises, whereupon a Closing Order is held to have become operative.

(*f*) If the landlord neither does the work nor closes the house, the S.A. may do the work and recover expenses. The landlord may appeal to the L.G.B.

(*g*) Definition of "*landlord*"—any person who lets a house or part of a house to a tenant under the terms of this part of the Act.

4. Closing and Demolition Orders.

(*a*) S.A.'s must have their districts inspected for houses unfit for habitation, and must make Closing Orders when such houses are found.

N.B.—The S.A. does not need to apply to a justice for a Closing Order, as under the P.H.A., 1875.

(*b*) Copies of such Orders must be served on all owners, who may appeal to the L.G.B. within fourteen days of receipt.

(*c*) Notice of a Closing Order must be served on all tenants, who must leave within the time fixed, being not less than fourteen days. Allowance for removal expenses may be paid to the tenant by the S.A., who may recover the money from the owner.

(*d*) Once the house has been made fit, the S.A. shall terminate the Closing Order.

(*e*) After a Closing Order has been three months in operation (or six months if the owner promises to do the necessary work), or if the continuance of the house is a nuisance to the health of the public, the S.A. may make a Demolition Order. Notice of the Order must be served on each owner, and appeal to the L.G.B. is allowed within twenty-one days.

(*f*) **Underground rooms**—a room habitually used as a sleeping-place, the floor of which is more than 3 feet below street level, is deemed unfit for habitation, and a Closing Order must be made if (*a*) it is not on an average 7 feet high, and (*b*) it does not comply with the regulations of the S.A. (made with the

consent of the L.G.B.) regarding ventilation, lighting, and protection from dampness and effluvia. If the S.A. fail to make regulations when required to do so, the L.G.B. may make them, and the S.A. must carry them out. Such underground rooms are closed only for sleeping purposes.

N.B.—Such rooms need not be let separately, as in Sec. 71 of P.H.A., 1875.

5. Owners of houses used solely as lodgings for the working-classes at a charge of not more than sixpence per head per night are exempt from inhabited house duty, provided the house is certified as being only so used and as providing suitable accommodation and fulfilling all sanitary requirements.

6. **Back-to-back houses** may not be erected unless the M.O.H. certifies they are so constructed and arranged as to secure proper ventilation of all habitable rooms.

Part II.—Town Planning.

Part III deals with the appointment of county M.O.H.'s and with the formation of Public Health and Housing Committees of C.C.'s.

HOUSING, TOWN PLANNING, ETC., ACT, 1919

Part I

1. Within three months of the passing of the Act every Local Authority must prepare and submit to the L.G.B. a scheme for the exercise of their powers under Part III of the H.W.C.A., 1890. The scheme must state the approximate number and nature of the houses to be provided, the approximate quantity of land to be acquired, the average number of houses per acre, and the time within which the scheme will be carried into effect. In default the L.G.B. may themselves act.

2. If the plans and specifications for a housing scheme, as approved by the L.G.B., do not comply with the local building bye-laws, these bye-laws are to that extent superseded.

3. Power is given to purchase houses for conversion into working-class dwellings.

4. The compulsory acquisition of land is made easier and, in the case of a slum area requiring to be closed, the price to be paid for it is the value of the land alone as a site for dwellings for the working-classes without any payment for the buildings. If the whole of the slum site is not required for rehousing, then that portion not required should be paid for at its full value, *e. g.* as a factory site.

Landowners themselves, who have insanitary slum property on their land, may apply to court for an authority to carry out any necessary improvements, and the court may even terminate

the lease and allow the landowner to take possession of the property with a view to improving it.

5. Whatever loss is incurred by a Local Authority over a housing scheme, it will not be necessary to call for more than a penny rate to meet this, provided reasonable expenditure has been incurred and proper rents are being charged.

6. The L.G.B. may call on a county M.O.H. to inspect any insanitary area in a county where the Local Authority have failed to act.

7. Bye-laws under Sec. 90 of the P.H.A., 1875, dealing with houses let in lodgings for the working-classes, may be made regarding—

(*a*) Number of occupants in a house, or part of a house, which is let in lodgings or occupied by members of more than one family, and separation of the sexes.
(*b*) Registration and inspection of such houses.
(*c*) Drainage, cleanliness, and ventilation.
(*d*) Adequate and readily accessible closet accommodation. Water supply and washing accommodation, and accommodation for the storage, preparation, and cooking of food.
N.B.—Where necessary, separate accommodation as aforesaid may be secured for every part of such house occupied as a separate dwelling.
(*e*) Keeping in repair, and adequate lighting of, any common staircase in such houses.
(*f*) Securing stability, and prevention of, and safety from, fire.
(*g*) Cleansing and redecoration of the premises at stated times, and paving of yards.
(*h*) Provision of handrails, where necessary, in staircases.
(*i*) Securing adequate lighting of all rooms.

When the owner, or other person on whom these bye-laws may impose duties, fails to execute any necessary work, the Local Authority may, after at least twenty-one days' notice, enter, do the work themselves, and recover expenses.

8. If the owner of any house[1] suitable for occupation by persons of the working-classes fails to keep such house reasonably fit for habitation, the Local Authority may require him within a reasonable time (not less than twenty-one days) to execute any necessary works. The owner may, within twenty-one days of receipt of such notice, declare his intention of closing the house,[2] whereupon a Closing Order shall be deemed to have become operative.

[1] N.B.—No rent restriction, as in the 1909 Act.
[2] Allowable only if the house is not capable, without reconstruction, of being rendered fit.

9. In houses used for occupation by the working-classes, the name and address of the M.O.H. and of the landlord, or other person directly responsible for keeping the house fit for habitation, shall be inscribed in every rent-book or handed in writing to the tenant before any rent is collected.

Part II deals with Town Planning. A Local Authority need not now obtain the authority of the L.G.B. for preparing or adopting a town-planning scheme. Every borough and urban district with a population over 20,000 must prepare a scheme by January 1, 1926. If a Local Authority fail to carry out their duties under this part of the Act, the C.C. or L.G.B. may act in their stead, and recover expenses.

INFECTIOUS DISEASES

Notification

Infectious Diseases Notification Act, 1889.—Diseases notifiable to the M.O.H.—

1. Small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever, typhus, enteric, relapsing fever, continued fever, and any other infectious disease the S.A. may add with the approval of the L.G.B.

By order of the L.G.B., plague (1900), cerebro-spinal meningitis, acute poliomyelitis, tuberculosis (1912), ophthalmia neonatorum (1914), measles and German measles [1] (1915), encephalitis lethargica (1918), malaria, dysentery (bacillary or amoebic), trench fever, acute primary pneumonia, and acute influenzal pneumonia (1919), have been added to the list.

(Anthrax, glanders and farcy in animals must be notified by Veterinary Surgeons to the M.O.H. under the Animals (Notification of Disease) Order, 1910, of the Board of Agriculture. Anthrax in workpeople and various industrial poisonings must be notified to the Chief Inspector of Factories under the F. and W. Act.)

2. Notification is necessary when a case of notifiable disease occurs in any building used as a human habitation, including ships, tents, vans, etc. Fever hospitals and ships belonging to H.M.'s or any foreign Government are exempt.

3. Persons responsible for notification are—

(*a*) Head of the family, or nearest relative, or
(*b*) Person present in attendance on the patient, or
(*c*) Occupier of the building.

If a medical practitioner is called in, he *must* notify.

4. Notification must be made *at once* on a prescribed form supplied free of charge, and 1*s*. per certificate is paid for cases in public practice, and 2*s*. 6*d*. in private. Penalty of 40*s*. for default.

[1] Notification ceased Dec. 31, 1919.

5. Before the S.A. make notifiable any other infectious disease, each member of the Council must have fourteen days' notice of the meeting (three days in the case of sudden emergency). A statement to the effect that the disease has been made notifiable must be advertised locally, and must be sent to every practitioner in the district. Notification is compulsory one week after the first advertisement. L.G.B. must approve.

Disinfection and Prevention Generally

P.H.A., 1875.

1. Sec. 120.—If the M.O.H. or medical practitioner certifies that disinfection would tend to prevent infectious disease, the S.A. must notify any owner or occupier of a house, or part of a house, to disinfect it and any articles therein. Penalty for default, and the S.A. may do the disinfection and recover expenses. (Disinfection may be done by the S.A. free of charge.)

2. The S.A. may destroy infected bedding, etc., and compensate the owner.

3. The S.A. may provide ambulances for free removal of infected persons to hospital.

4. On the certificate of a practitioner, a justice may order the removal to hospital of any case of infectious disease on board a ship, or without proper lodging, or living in a room occupied by more than one family. Removal compulsory without a justice's order in the case of a common lodging-house.

5. The S.A. may make regulations for the removal to, and detention in, a hospital of any infected person on board ship. Regulations must be approved by the L.G.B.

(P.H.A. (A.) A., 1907 (adoptive), extends removal to all infected persons in any premises where proper isolation is impossible.)

6. Penalties incurred for the following acts—

(*a*) Wilful exposure (either of oneself or person of whom one has charge), while suffering from a dangerous infectious disease, in any street, public place or public conveyance, or entering any public conveyance without first notifying the condition to the driver, etc.

(*b*) Giving, lending, selling, transmitting, or exposing infected bedding, clothing, rags, etc.

(*c*) Failure to disinfect a public conveyance after being used by an infected person.

(*d*) Letting any infected house or part of a house (including inns) before disinfection.

(*e*) Making false statements when letting a house infected within the previous six weeks.

7. **Epidemic Disease.**

Sec. 130.—The L.G.B. may make, alter or revoke regulations

for the treatment of cholera, or any other epidemic, endemic or infectious disease, and for preventing the spread of disease on land or sea, rivers and waters of the United Kingdom, or on the high seas within three miles of the coast.

8. Sec. 134.—Whenever any part of England appears to be threatened by any formidable endemic, epidemic, or infectious disease, the L.G.B. may make, alter, or revoke regulations for (1) speedy interment of the dead, (2) house to house visitation, (3) provision of medical aid and accommodation, (4) disinfection, cleansing, and ventilation, and (5) guarding against the spread of the disease.

Infectious Diseases Prevention Act, 1890 (adoptive), does not apply to London.

Sec. 4 deals with milk supplies, and has already been noted (p. 286). Other provisions are—

1. On the certificate of M.O.H. or practitioner that cleansing and disinfection of a house and contained articles would prevent the spread of infectious diseases, the S.A. may notify in writing the owner or occupier that unless he does what is necessary within twenty-four hours, they themselves will do so at his expense. The S.A. may do the work gratuitously if the individual is unable.

2. S.A. may by notice require the owner of infected bedding, etc., to deliver it to their officers for disinfection. Articles will be returned, and no charge made. Compensation for any unnecessary damage.

3. Penalties inflicted on any one leaving a house, infected within the previous six weeks, who

   (*a*) fails to disinfect house and contents,
   (*b*) fails to notify the owner, or
   (*c*) gives false answers to prospective tenants.

4. Infected corpses not to be kept more than forty-eight hours elsewhere than in a public mortuary. They may be kept in a room, not used as a dwelling-place, sleeping-place, or work-room, with the written consent of the M.O.H. or a practitioner.

5. In contravention, or in the case of a corpse likely to injure the health of a household, the M.O.H. may apply to a justice for an order for its removal within a fixed time.

Corpses from an infectious hospital may be required to be conveyed direct to the burial-ground, if a medical practitioner considers this advisable.

6. No public conveyance, other than a hearse, may be used for conveying an infected corpse.

7. A justice may order the detention in hospital, for a fixed time and at the cost of the S.A., of any one already in hospital suffering from an infectious disease, provided he has no place to go to where proper precautions can be taken against spread-

ing infection. The time may be extended if necessary, and the order be enforced.

The P.H.A. (A.) A., 1907 (adoptive), includes the following provisions—

If the M.O.H. considers that infectious disease is attributable to a milk supply, the S.A. may require the dairyman to furnish the M.O.H. with a complete list of all farms, etc., from which he has obtained milk within the previous six weeks. Every dairyman must notify the M.O.H. of any case of infectious disease among his employees. No infected bedding, etc., may be sent to a public laundry till disinfected. Children exposed to infectious disease may by notice be excluded from school till the M.O.H. certifies they may attend. The principal of a school in which there is a case of infectious disease may be required to furnish the S.A. with a list of the names and addresses of all day scholars. Public library books must not be used by an infected person, and, if they have been so used, the S.A. must be notified. No person, knowing he is suffering from an infectious disease, shall engage in any occupation where he may spread infection. No wakes may be held over infected corpses. A S.A. may establish a "reception house," and, if necessary, obtain a justice's order for removal of contacts to such house.

Cholera, etc., Regulations.—Power to make these regulations given to the L.G.B. by Sec. 130, P.H.A., 1875, extended by the P.H.A., 1896 (which also repealed all quarantine enactments), and by the P.H.A., 1904.

"**Infected ship**" is one which, on arrival at port, has on board a case of cholera, plague, or yellow fever, or which has had on board a case of cholera or plague within seven days, or a case of yellow fever within eighteen days, prior to arrival.

"**Suspected ship**" is one which has had on board during the voyage a case of cholera, plague, or yellow fever, but has not had a fresh case of cholera or plague within seven days, or of yellow fever within eighteen days, of arrival in port.

1. **Customs officers** must ascertain if a ship is "infected," or "suspected," or if it has called at an infected port. They must detain the two former, and may detain the latter, and order the master to moor in a fixed place. Notice to be given to the S.A.

2. **Port S.A.**'s must arrange for a special mooring-place for infected ships, and make provision for reception of infected persons.

3. (*a*) **The M.O.H.** must at once examine the ship, if infected or suspected. If it has come from an infected port he may examine it. In the case of an infected or suspected ship, he must give a certificate to that effect to the master, and give a copy to his S.A. He must also notify the L.G.B. of the arrival. The

master must then moor at the special moorings. As soon as possible the M.O.H. must examine every one on board—no one is allowed to leave before examination.

(*b*) If an infected person is found, he must if possible be removed to hospital. Otherwise the ship remains under the control of the M.O.H., and no one can leave without his written consent.

(*c*) Suspected persons may be detained on the ship, or in a hospital or other suitable place, not longer than two days to enable a diagnosis to be made.

(*d*) Before landing, all persons must give the M.O.H. their names and their addresses at place of destination. The clerk of the S.A. must transmit these to the S.A. of the place of destination. If the person arrives, within forty-eight hours of his landing, at an address other than the one he gave to the Port M.O.H. he must notify the M.O.H. of the district in which he now is.

(*e*) The M.O.H. must take all precautions to prevent spread of disease—disinfection or destruction of bedding, etc., disinfection of ship and articles therein, proper disposal of infected dead bodies. A reasonable charge may be made by the S.A. for work done.

(*f*) The M.O.H. may by certificate prevent the landing of persons from suspected ships, or of filthy or unwholesome passengers from any ship, or of persons from a ship having a large mortality among rats.

(*g*) The M.O.H. may order bilge and water-ballast to be pumped out, and water-tanks to be cleansed in the case of ships suspected of cholera, and order rats to be destroyed in the case of a plague-infected ship. If he orders rats to be killed in a plague-suspected ship, the expenses must be met by the S.A. Rats must be prevented from landing from such ships. Mosquitoes and their larvæ must be destroyed in the case of yellow fever.

(*h*) Penalties for giving false replies to the M.O.H.

4. **The master** of an infected or suspected ship must between sunrise and sunset hoist at the masthead a large flag of yellow and black. Between sunset and sunrise he must place, not less than 20 feet above the hull, three lights, each six feet apart, in the form of a triangle—apex light white and the base lights red.

Penalty for neglect.

5. **Outward-bound ships.**—Within twelve hours of receiving a written request from the master of a ship in an infected area, the M.O.H. must visit the ship, and examine all persons on

board, and any articles that may have been exposed to infection. He shall then give a certificate to the master stating whether the ship is free from infection or not, etc. Certain sums for such certificates may be charged by the S.A.

The Aliens Act, 1905.—Aliens may be landed only at ports where special Immigration Officers have been appointed. This officer, accompanied by a M.O., must inspect all aliens before landing, and decide whether or not they are to be allowed to land. There is right of appeal to the Immigration Board in the event of landing being refused.

Undesirable aliens are (*a*) those who cannot show means of supporting themselves decently, (*b*) those suffering from some disease which is likely to throw them on the rates, (*c*) those who have been sentenced in a foreign country for some non-political offence, and (*d*) those against whom an expulsion order under the Act has been made by the Secretary of State.

Public Health (Tuberculosis) Regulations, 1908 and 1911, issued by the L.G.B. under Sec. 130, P H.A. (See p. 170.)

The Public Health (Pneumonia, Malaria, Dysentery, etc.) Regulations, 1919 (under Sec. 130, P.H.A., 1875), in force after March 1, 1919.—These regulations make notifiable malaria, bacillary and amœbic dysentery, trench fever, acute primary pneumonia, and acute influenzal pneumonia.

The M.O.H. is to make all investigations necessary, and take proper measures for prevention. He must notify the L.G.B. of the names and addresses of all cases of trench fever and malaria contracted in the United Kingdom, and of all persons affected in an outbreak of dysentery. He must also see that persons suffering from these three diseases receive proper treatment in hospital or elsewhere.

Malaria.—The M.O.H. must see that all cases of malaria are supplied with sufficient mosquito-netting and receive full quinine treatment. If two or more cases appear to be contracted in a district, the S.A. may appoint an approved medical practitioner to visit suspected houses and offer to examine the inmates and endeavour to get specimens of blood for diagnostic purposes.

Dysentery and Enteric Fever (includes Paratyphoid).—The M.O.H., in the event of an outbreak, may by written notice (*a*) prohibit the employment of specified individuals in connection with occupations where food is prepared, (*b*) exclude the children of specified persons from school, and (*c*) order the taking of suitable measures with regard to disposal of excreta, destruction of flies, and prevention of contamination of food.

With regard to suspected dysentery, typhoid, and paratyphoid carriers, the M.O.H. may, by written notice to the manager of a business where such persons are employed, certify that it is necessary to make a clinical examination. If the examination, clinical or bacteriological or protozoological, is positive, the

M.O.H. may, by written notice, prohibit the employment of such persons in any business where food is handled.

Trench Fever.—The M.O.H. may, by written notice, require complete disinfection of the premises, where the case occurred, and of the occupants. Contacts may be temporarily segregated till disinfected. Similar powers are granted with regard to typhus fever and relapsing fever. Notification of cases of these two diseases must also be sent to the L.G.B.

Venereal Disease Act, 1917, aims at preventing the treatment of venereal diseases otherwise than by duly qualified medical practitioners, and at controlling the supply of remedies.

Venereal disease includes syphilis, gonorrhœa, or soft chancre.

1. Once a scheme for the gratuitous treatment of venereal disease in any area has been approved by the L.G.B., the L.G.B. may, by order, prohibit persons for reward, direct or indirect, in that area, other than qualified medical practitioners, from treating cases of venereal disease, and from giving remedies or advice, whether the advice is given to individuals to be treated or to any other persons.

2. No person may advertise in any way treatment, or offer of treatment, for venereal disease, and after November 1, 1917, no medicine, whether for internal or external use, may be advertised for the prevention, cure, or relief of such disease.

3. Severe penalties for contravention. (See also p. 186.)

HOSPITALS

P.H.A., 1875.—Any S.A. may build hospitals or contract for hospital accommodation. Two or more S.A.'s may combine for these purposes. Cost of maintenance in hospital may be recovered from all treated persons other than paupers.

N.B.—Infectious disease hospitals not specified.

Isolation Hospitals Acts, 1893 and 1901.—These Acts give certain powers to C.C.'s to provide fever hospitals. They do not apply to any county borough, but do apply, with consent of the Town Council, to boroughs of over 10,000 population, and to boroughs of less than 10,000, if the L.G.B. so direct.

Twenty-five or more ratepayers in a contributory place, or any S.A. in the county, may apply to the C.C. for the establishment of a fever hospital. A local inquiry by the C.C. follows, and a special report is usually required from the county M.O.H. If satisfied that a hospital is necessary, the C.C. make an order constituting a hospital district, and directing a hospital to be established. A copy of this order must be sent to the L.G.B. A Hospital Committee is formed by the C.C. to manage the hospital. Such hospitals must be provided with an ambulance, and a telegraph system must be available. Temporary structures may be provided to accommodate patients during epidemic periods.

Power is given to the C.C. to borrow money for these purposes, and to contribute to the expense of the hospital. Arrangements are made for recovering patients' maintenance expenses from the various S.A.'s concerned.

N.B.—A "**contributory place**" means parishes or parts of parishes in rural districts for which public sanitary works have been carried out, and which are liable to a special rate in consequence.

MORTUARIES

P.H.A., 1875.—1. Every S.A. may, or if so required by the L.G.B. must, provide a mortuary, and may make bye-laws for its management. The S.A. may also arrange for the burial of bodies received.

2. On a medical practitioner's certificate, a justice may order removal to a mortuary, and burial within a specified time, of a body—

(*a*) dead of an infectious disease, and retained in a living- or sleeping-room;

(*b*) in such a state as to endanger the health of the inmates of the house where it lies.

In default, the Relieving Officer may arrange the burial and recover expenses from the relatives.

3. Any S.A. may provide a *post-mortem* room.

Memorandum regarding Mortuaries (by L.G.B.).—1. Building should be isolated, unobtrusive, and of substantial structure.

2. There should be a ground-floor room for bodies, a waiting-room for visitors, a caretaker's house, and a shed for keeping shells, etc.

3. There should be a ceiling or double roof with an 8-inch space, ventilation by louvres or gratings under the eaves, and north light.

4. Well-paved floor, water laid on, internal walls whitewashed.

5. There should be one chamber for infected bodies, and another for bodies dead from any other cause.

6. Bodies must be received at any hour, and a proper register with all particulars must be kept.

7. Shells must be thoroughly cleansed.

Model Bye-laws provide for the removal of bodies within certain times, etc.

DISPOSAL OF THE DEAD

Earth Burial

Burial Act, 1853.—On the representation of the Secretary of State, an Order in Council may be made prohibiting the opening of a new burial-ground within a city, and ordering discontinuance of burials in certain places.

Regulations of the Home Office require—

(*a*) At least 9 feet by 4 feet for adults over twelve.

(*b*) At least 6 feet by 3 feet for children under twelve.

(*c*) At least 1 foot between each grave.

(*d*) No unwalled grave may be reopened within fourteen years after the burial of an adult, or eight years after the burial of a child (under twelve), unless for interment of another member of the same family, when at least one foot of earth must be left above the previous coffin.

(*e*) No coffin in an unwalled grave must come within 4 feet of the surface (within 3 feet, in the case of a child under twelve).

P.H. (Interments) A., 1879.—Any S.A. may—if required by the L.G.B. must—provide a cemetery and make bye-laws regarding its management.

Cemetery Clauses Act, 1847.—No part of a cemetery must be within 100 yards of a dwelling-house, save with the consent of the owner and occupier.

The cemetery must have walls or railings 8 feet high, and be properly drained.

Model Bye-laws (under P.H. (Interments) A.) have been issued.

Cremation

The Cremation Act, 1902.—1. Site and plans of any crematorium must be approved by the L.G.B., and the premises must be certified to the Secretary of State by the burial authority as complete in every way.

2. None to be constructed within 200 yards of a dwelling-house save with consent of owner and occupier, or within 50 yards of a public highway.

3. Regulations to be made by Secretary of State.

4. Penalties to be inflicted on persons who, by false representation, etc., endeavour to procure the burning of any body.

Regulations, 1903.—1. Premises to be open for inspection by officers duly appointed by the Secretary of State or L.G.B.

2. Unlawful to cremate any unidentified remains, or the body of any one who has left written instructions to the contrary.

3. Formalities to be observed before cremation can take place—

(*a*) Registration of death, except when Coroner gives a certificate after an inquest.

(*b*) Application must be made, and statutory declaration signed, by an executor or nearest relative.

(*c*) Special certificate from practitioner in attendance confirmed by a certificate from a specially appointed Medical Referee or other specially qualified practitioner.[1] The confirmatory certificate is unnecessary

[1] *E.g.*, M.O.H. or Police Surgeon.

if a post-mortem examination has been duly performed, or an inquest has been held.

(*d*) The Medical Referee is responsible for seeing that everything is in order, and that cremation is not performed on a body which might later be required for medico-legal purposes.

MIDWIVES ACT, 1902

1. (*a*) After April 1, 1905, no woman, unless certified under this Act, shall use the name of midwife or anything implying that she is specially qualified to practise midwifery.

(*b*) After April 1, 1910, no woman, unless certified, shall, habitually and for gain, attend women in childbirth save under the direction of a medical practitioner.

(*c*) No woman shall be certified until she has complied with the rules and regulations laid down under this Act.

2. A Central Midwives Board to be established to deal with all matters regarding training, examining, certifying, regulating, and suspending midwives.

3. The local supervising authority is the Council of a County or County Borough. A C.C. may delegate any of its duties in this respect to a District Council.

NOTIFICATION OF BIRTHS ACT, 1907

(This Act, formerly adoptive, ceased to be so on the passing of the Extension Act in 1915, which also provided for the establishment of Maternity and Child Welfare schemes.)[1]

1. The birth of any child, alive or dead, after the twenty-eighth week of pregnancy, must be notified in writing to the M.O.H. of the district within thirty-six hours by (*a*) the father of the child, if he is resident in the house at the time, or (*b*) any person in attendance on the mother within six hours of the birth.

2. The S.A. must supply stamped and addressed post-cards printed in a special form to all practitioners and midwives in the district, on application.

3. This notification is not a substitute for the ordinary registration of births, and the local Registrar may inspect all notices of births received by the M.O.H.

4. Penalty of 20*s*. for default unless the person charged can prove he had reason to believe that some other person had sent the notice.

VACCINATION ACTS, 1867, 1871, 1898, AND 1907

1. Boards of Guardians to appoint Public Vaccinators, and to administer these Acts under the L.G.B.

[1] See p. 131.

2. Children to be vaccinated within six months of birth—if requested, the Public Vaccinator must visit the house to vaccinate the child. The P.V. must, after twenty-four hours' notice, visit any house where there is an unvaccinated child four months old, and offer to vaccinate with L.G.B. lymph. If house conditions, or the prevalence of infectious disease, render the operation unsafe, the P.V. must not vaccinate, in either of which cases he must notify the M.O.H. For these two reasons, or if the child is not in a fit state, the P.V. may postpone vaccination for not more than two months, a certificate of postponement to be sent to a special officer appointed, and a copy to be given to the parents on demand.

3. If vaccination proves unsuccessful after three attempts, or if the child has already had small-pox, the P.V. must within seven days of examination send a certificate to that effect to the special Vaccination Officer. So too, within seven days, a certificate of successful vaccination must be sent. When the services of the P.V. have not been utilised, the parents must themselves send these certificates, signed by a medical practitioner.

4. If within four months of the birth of a child a parent or guardian makes a statutory declaration, before a Commissioner for Oaths, that he conscientiously believes that vaccination would be prejudicial to the health of the child, and, within seven days, sends such declaration to the special Vaccination Officer, he shall not be liable for any penalty under the Act. Otherwise there is a penalty of 20*s*. for neglecting to have a child vaccinated. After conviction, no further proceedings can be taken till the child has reached the age of four years.

5. In the event of serious outbreaks of small-pox the L.G.B. may require the Guardians to provide special vaccination stations.

N.B.—The administration of the Vaccination Acts should be in the hands of the S.A. The "Dual Control" of small-pox refers to (*a*) vaccination under Boards of Guardians, and (*b*) all other preventive measures under the S.A.

The Public Health (Small-pox Prevention) Regulations, 1917, issued by the L.G.B. under Sec. 130 of the P.H.A., 1875, give power to any M.O.H. to vaccinate or re-vaccinate without charge any contacts of a case of small-pox, who are willing to submit themselves to the operation. In primary vaccination four vesicles should be produced about half an inch apart, and an area of vesiculation of not less than half a square inch should be aimed at. Should the person vaccinated require medical treatment as a result of the operation, the S.A. should offer to provide it.

A record must be kept by the M.O.H. of all vaccinations performed, and the L.G.B. suggest that he should be paid not less than 2*s*. 6*d*. for each vaccination.

THE CHILDREN ACT, 1908

Part I.—1. All persons undertaking for reward, for more than forty-eight hours, the nursing and maintenance of one or more infants under seven years, must within forty-eight hours notify the L.A. The notice must contain name, sex, and date of birth of infant, and other particulars. Any change of address must be notified within forty-eight hours, also the death or removal of any infant. All deaths must, in addition, be notified to the coroner within twenty-four hours, who shall order an inquest in the absence of a proper medical certificate.

2. Special inspectors to be appointed under the Act—with power of entry.

3. An inspector may apply to a justice for an order to remove an infant from unsuitable premises.

4. The L.A. may fix the number of infants to be kept, and may exempt certain premises from inspection.

5. Persons may not insure the lives of infants kept for reward.

Part II deals with cruelty to children, and includes overlying of infants under three years, and the provision of fire-guards in rooms where children under seven years are allowed.

Part VI includes cleansing of verminous children.

Any local Education Authority may direct their M.O. to examine the person and clothing of any child attending an elementary school. The authority may give notice in writing to the parent or guardian of an infested child, requiring him to cleanse the child and clothing within twenty-four hours. Such notice must explain how cleansing may best be done. In default, the M.O. may remove the child from school, and have the cleansing done in some suitable place. Penalty of 10*s*. for recurrence of the condition. S.A.'s, if they possess or have the right to use premises for cleansing, must allow such premises to be used under this part of the Act. Girls must be examined and cleansed by a medical practitioner or a specially authorised woman.

CLEANSING OF PERSONS ACT, 1897

A S.A. may permit any one, *on application*, to have the free use of any apparatus which the S.A. possess for the purpose of cleansing his person and clothing from vermin.

Any reasonable sum may be spent on buildings, appliances, and attendants.

SHOP-HOURS ACTS, 1892, 1893, 1895, 1912

"**Young person**" means a person under eighteen years.

"**Shop**" means retail and wholesale shops, markets, stalls, and warehouses, including licensed public-houses and refreshment-rooms.

1. No young person to be employed more than seventy-four

hours a week, including meal hours. A notice referring to the provisions of the Act must be hung in a conspicuous place in every shop where a young person is employed.

2. Seats must be provided for female assistants.

3. Three-quarters of an hour for dinner if taken on the premises, or an hour if taken out. Half an hour for tea.

4. Weekly half-holiday for every assistant.

5. Orders may be made fixing a particular day for half-day closing and fixing the closing hours at night.

FACTORY AND WORKSHOPS ACT, 1901

Definitions—

"Child" means a person under fourteen years.

"Woman" means a woman eighteen years and over.

"Young person" means a person over fourteen and under eighteen years.

"Factory" means all places where mechanical power is used, and includes certain other places, such as print works, earthenware works, lucifer match works, indiarubber works, whether mechanical power is used or not.

"Tenement factories" are buildings containing several factories occupied separately, but all drawing their mechanical power from a common source.

"Workshop" means a place where work is carried on for gain and where no mechanical power is used.

"Tenement workshops" include such places as tailors' workshops, where separate benches are hired by individuals who do work on their own account.

"Domestic workshops" mean places used for dwelling as well as for working purposes, in which are employed only members of the same family and in which no mechanical power is used. "Domestic factories" have the same meaning (the word factory here is consequently somewhat misleading).

"Workplace" is taken to mean any place where work is done permanently and where people assemble together to do any work permanently. This includes such places as kitchens of restaurants, stable-yards, etc.

N.B.—Factories are supervised through the Home Office by Factory Inspectors, workshops mainly by S.A.'s. Notice of occupation of a factory or workshop must be sent within a month to the F.I. of the district, who must forward notices regarding workshops to the S.A. Every factory and workshop must have affixed in it a prescribed abstract of this Act, and must keep a register showing any children and young persons employed, dates of lime-washing, etc. Every S.A. must keep a register of all workshops, and the M.O.H. must deal with these in his annual report, and send a copy to the Secretary of State. If the M.O.H. discovers that a woman, young person, or child

is employed in any workshop where the abstract of this Act is not affixed, he must notify the F.I. of the district.

Part I
Health

1. All factories, except domestic factories, must be kept clean and free from any drain effluvia, must not be overcrowded, and must be so ventilated as to render harmless all gases, dust, etc. Ceilings and inside walls must be lime-washed, and painted surfaces washed, at least once in every fourteen months.

2. All workplaces must be maintained in a clean state, and free from nuisances. If the M.O.H. certifies it is necessary, the S.A. may send notice to the owner or occupier of any workshop or workplace to whitewash and cleanse it within a specified time. Penalty for default, and the S.A. may do the work and recover expenses.

3. **Cubic Space in Factories and Workshops.**—Two hundred and fifty cubic feet per head, 400 for overtime. Overtime in underground bakehouses, 500 cubic feet. In the case of workshops, not being domestic workshops, which are used as sleeping-places as well, 400 cubic feet must now be supplied. The Secretary of State may also increase the amount in factories and workshops where artificial light, other than electric, is used. In every factory and workshop a notice must be shown specifying the number of persons to be employed in each room.

4. Reasonable temperatures must be maintained in all factories and workshops.

5. Adequate drainage for wet floors in factories and workshops.

6. Sufficient sanitary conveniences and proper to the number of workpeople in all factories and workshops with separate accommodation for each sex. The Secretary of State to determine what is "sufficient."

By the **Sanitary Accommodation Order**—

(*a*) One sanitary convenience for every 25 males or females.

(*b*) When males exceed 100, and sufficient urinal accommodation is provided, one closet for every 25 males up to the first 100, and one for every 40 after that.

(*c*) If males exceed 500 and there is proper control of the use of closets, one for every 60 will suffice, in addition to urinal accommodation.

(*d*) All closets must be kept clean, and must not communicate directly with work-rooms, must be under cover, and partitioned off (with a fastening door for females). Completely separate arrangements must be made for the two sexes.

7. If the Secretary of State considers that the S.A. are not carrying out their duties under the Act, he may authorise the

F.I. to enter any workshop or workplace, and take any necessary steps. Expenses to be recovered from the S.A.

8. Any default *re* drains, closets, water supply, nuisance, etc., in factories, remediable under the P.H.A., 1875, must be notified to the S.A. by the F.I. The S.A. must then take all necessary steps and notify the F.I. of what has been done. In the event of the S.A. taking no action within a month, the F.I. may do what is necessary and recover expenses from the S.A.

Safety.—S.A. must examine all factories and workshops, to see if proper means of escape are provided in the case of fire, and must compel owners to provide them.

Part IV

Dangerous and Unhealthy Trades

1. Compulsory notification by practitioners to the Chief Inspector of Factories at the Home Office of all cases of poisoning from lead, phosphorus, arsenic, or mercury, or of anthrax contracted in any factory or workshop.
2. Ventilation by fans in certain dusty processes in factories and workshops, *e. g.* glazing, grinding, polishing.
3. Suitable lavatories where poisonous materials like lead and arsenic are used, and prohibition of eating, or remaining during meal-times, in rooms where dust from such may be inhaled or other dangerous processes are carried out.
4. Restrictions regarding employment of children, young persons or women in certain trade processes.

Part V

Bakehouses must comply with the following regulations—

(*a*) No closet, etc., to be within or communicate with any bakehouse. No drain may open within a bakehouse.

(*b*) No cistern supplying water to the bakehouse must supply water to a water-closet.

(*c*) No place on the same level with a bakehouse, and forming part of the same building, to be used as a sleeping-place, unless it is completely separated, and has an external window 9 square feet in area, of which at least half must open.

Underground Bakehouses

"**Underground bakehouse,**" where the surface of the floor is more than 3 feet below the adjoining ground or street.

(*a*) No underground bakehouse shall be used as a bakehouse unless so used at the passing of the Act, and none shall be used after January 1904 unless certified by the S.A. as suitable regarding construction, light, ventilation, etc.

(*b*) Any person refused a certificate by the S.A. may appeal within twenty-one days to a court of summary jurisdiction.

(*c*) The S.A. enforce all provisions regarding underground bakehouses, which are considered to be workshops under the Act.

(*d*) Five hundred cubic feet of space per head during overtime.

Laundries (as modified by the F. & W.A., 1907).

(*a*) Women and young persons not to be employed more than sixty hours a week, or children more than thirty.

(*b*) Fans to be employed if mechanical power is used; stoves for heating irons to be separate from any ironing-room, and gas-irons giving out harmful fumes not to be used; floors to be in good condition and properly drained.

(*c*) The provisions of the F. & W.A., 1901, regarding health, safety, etc., are applicable to all laundries carried on for gain, and even to institutional laundries where work is done other than for the use of the institution itself, even if not done for gain.

Exempted: institutional laundries where only the washing, etc., of the soiled clothing of the institution is done, and places where washing is done by members of the same family or where not more than two persons dwelling elsewhere are employed.

(*d*) S.A. supervise all laundries without mechanical power—which are considered as workshops.

Cotton, Cloth and other Humid Factories.—Where artificial humidity is produced, wet- and dry-bulb thermometers must be provided and read thrice daily; certain maximal humidities according to the temperatures are laid down, and CO_2 must not exceed 0·09 per cent.

Part VI

Home Work

In certain industries specified by the Secretary of State—

(*a*) The occupier of every factory and workshop, and every contractor employed by him, must keep a list of the names and addresses of all persons employed as "out-workers," and must send copies of each list to the S.A. on or before February 1 and August 1 each year. Such lists to be open to inspection by the F.I. or S.A.

(*b*) The S.A. must send the names and addresses of all out-workers to the S.A. of the district where they actually reside. The lists kept by the S.A. are open to inspection by the F.I.

(*c*) S.A. may prohibit home work in premises which are injurious to the health of the workers.

(*d*) Penalties inflicted on any employer who knowingly allows wearing apparel to be made, cleansed, or repaired in any house where there is a case of small-pox or scarlet fever.

(*e*) S.A. may make an order prohibiting the giving out of work (dealing with wearing apparel) to any out-worker living in a house where there is a case of notifiable infectious disease. This order is to be served on the person who gives out the work, and

may be made out for a specified time or till the house has been properly disinfected.

ALKALI WORKS REGULATION ACT, 1906

"**Alkali works**" includes those where HCl is evolved, sulphuric acid works, chemical manure works, gas liquor works, nitric acid works, etc. These must be registered by the L.G.B., and special inspectors are appointed by the L.G.B. with right of entry.

In alkali works not more than $\frac{1}{5}$ grain of HCl must be present per cubic foot of smoke, etc., given forth. In sulphuric acid works such smoke, etc., must not contain more than the equivalent of 4 grains of SO_3 per cubic foot.

Provision also is made for preventing nuisance from depositing or discharging waste matters.

RAG FLOCK ACT, 1911

No person may sell or use rag flock for making upholstery, bedding, etc., unless the flock conforms with the following regulations made by the L.G.B. in 1912: When not less than 40 grams of flock are thoroughly washed with distilled water at a temperature below 25° C. the chlorine must not exceed 30 parts per 100,000 of flock. This standard ensures a certain degree of cleanliness.

RATS AND MICE (DESTRUCTION) ACT, 1919

Every occupier of land or buildings is required to take such steps as may from time to time be necessary and reasonably practicable for the destruction of rats and mice on or in any lands or buildings of which he is the occupier, or for preventing such land and buildings from becoming infested with rats or mice. In default, penalty not exceeding five pounds.

Any occupier who has been served with a notice under this Act, and who fails to take such steps as are prescribed in this notice, is liable to a fine not exceeding twenty pounds.

THE MIDWIVES ACT, 1918

This Act contains the following provisions: Where a midwife has been suspended from practice to prevent the spread of infection, the Central Midwives Board or the local supervising authority may pay her reasonable compensation. The C.M.B. may prohibit any midwife, whose name has been removed from the roll, from attending women in child-birth in any other capacity (appeal allowed). A local supervising authority may make grants for the training midwives, whether within or without their area. In case of emergency a midwife shall call in a registered medical practitioner and the local supervising authority shall pay him fee and mileage according to the L.G.B. scale, such fee to be recoverable from the husband as a civil debt save in necessitous cases.

SECTION X

METEOROLOGY, PHYSICS AND CALCULATIONS

METEOROLOGY

By climate is meant the sum of all meteorological and telluric conditions. A place may experience bad weather, and yet have a good climate. The determining factors, all of which have modifying influences, are, latitude, altitude, proximity to the sea and mountain ranges, the distribution of land and water, ocean currents (the Gulf Stream tempers the climate of the British Isles), prevailing winds, the nature and the cultivation of the soil. The rainfall also depends largely on these conditions, and also on the amount of afforestation. Hence the difference between the rainfall of the west and east of the British Isles.

An " isotherm " is a line connecting places which have the same mean annual temperature. An " isocheimonal " is an isothermal line for mean winter temperatures, and an " isotheral " is an " isotherm " for the mean summer temperatures. The mean annual temperature of a place depends largely upon its latitude and altitude. As the temperature falls 1° F. for every 280 feet of ascent, it is obvious that there must be a height, in relation to the latitude, where the temperature never exceeds 32° F., and consequently snow never melts. This " snow line " is at the sea-level in the arctic regions, and no less than 16,000 feet up at the equator. Radiant heat is received from the sun from the time it rises to the time it sets. The maximum temperature is reached about 2 p.m. and the minimum shortly before sunrise. It has been found that the mean daily temperature is approximately the average of any two hours which have a twelve-hourly interval, 10 a.m. and 10 p.m., for example. The mean annual temperature for the British Isles is about 48° F. This equability is due to the fact that we are surrounded by water. The heat-absorbing capacity of water is at least four times as great as that of land. The temperature of the sea is gradually raised during the summer, and lowered during the winter. Land, on the other hand, has diurnal changes, rapidly absorbing heat in the daytime, and giving it up with equal rapidity during the night.

These different specific heat values account for the phenomenon of land and sea breezes. During the hours of sunshine the air over the land is warmer than the air over the sea with a consequent disequilibrium. In obedience to the law that air travels from the point of low temperature to that of high, a sea breeze is set up. The reverse direction takes place during the night, as the temperature of the air over the sea is now the higher. Any air in motion, or wind, is due to this inequality of temperature or density, and the greater the disparity between the temperatures or densities, the higher the velocity of the wind. By the action of winds the homogeneity of the earth's atmosphere is maintained. The permanent or trade winds are due to the fact that the region near the equator, subjected to the vertical rays of the sun, is more intensely heated than any other zone nearer to the poles. The air at the equator therefore ascends, the colder or denser air flowing in from north and south in its endeavour to restore uniformity. In that way four currents are created, two under currents travelling from the poles to the equator, and two others in the higher regions travelling polewards. The former two constitute the trade winds. If the earth did not revolve, the air from the north pole would take a due south course to the equator, and that from the south pole a due north course. But as the earth revolves from west to east, these winds proceed into zones, which have greater velocities of rotation than they themselves possess, and so they lag behind, or are deflected towards the west. It is obvious that the rotatory velocity of the equator is greater than that of any other line of latitude. In consequence of this the wind from the poles is unable to keep up, as it were, with each new and increasing velocity the nearer it reaches the equatorial regions. The wind from the north, therefore, becomes north-easterly, and that from the south south-easterly.

An "isobar" is a line connecting places which have the same barometric pressure. A cyclone may be regarded as a series of concentric isobars with the lowest pressure in the centre.

"Barometric gradients" may be expressed in decimal parts of an inch of mercury per 15 nautical miles. They are regarded as slight or moderate when they are 0·01 inch, and steep when they exceed 0·02 of an inch. The steeper the gradient the higher the velocity of the wind.

Of recent years a new pressure measurement has been introduced in place of inches and parts of an inch—isobars being drawn at intervals of so many millibars. The "bar" = 100 centibars = 1000 millibars = 29·53 inches = 750·1 millimetres.

A cyclonic area then is one where unequal pressures prevail, and consequently air is set in motion. The wind thus originated travels from the periphery of the area to the centre. That starting from the north is deflected towards the south-west,

on account of the rotation of the earth, and that from the south towards the north-east for the same reason. These deflections cause the air to revolve in a direction anti-clockwise in the northern hemisphere. One of the first indications of an approaching cyclone is a falling barometer, the rate of fall depending upon the gradient of the pressures. The exact point of entry can be determined by noting the changes of the direction of the wind. If we are in the track of the southern half of the cyclone, then the wind changes from the south to south-west to west. The sky becomes gloomy, and heavy rainstorms are experienced. With a rise of the barometer, the centre of the cyclone has passed, and the wind assumes a more northerly direction, the sky clears, and fine weather once more prevails. An anti-cyclone in the northern hemisphere revolves clockwise. It consists of an area of unequal pressures, the highest being in the centre. Good weather usually accompanies it. The directions of rotation are reversed in the southern hemisphere.

Secondary types of isobars such as V-shaped depressions, wedges, cols, secondary cyclones, and straight isobars, are modifications of the two primary types, the cyclonic and anti-cyclonic.

Isobars may run parallel to each other in a straight line for many hundreds of miles. If they should embrace an area of low pressure by curving into the shape of the letter V, such a system is called a V-shaped depression. Cyclonic systems very often follow each other in rapid succession, and are divided by an area of high pressure. The area assumes the shape of an inverted V, hence it is called a "wedge." It is probably due to a projecting isobar from a neighbouring anti-cyclone. If two anti-cyclones are connected by an area of relatively low pressure, this system is called a "col." In the event of one or more isobars from a primary cyclone curving outwards and forming in themselves an area of low pressure, a secondary cyclone or a subsidiary depression is established.

Buys Ballot's Law states that if you stand with your back to the wind, the point of lowest pressure is on your left hand in the northern hemisphere, and on your right hand in the southern hemisphere.

The **rainfall** is measured by means of a rain gauge, and is expressed in terms of inches and parts of an inch down to one hundredth. If less than the latter amount falls during the twenty-four hours, it is considered a rainless day. The rainfall of the south-west of England is high because the wind which prevails is moisture-laden after passing over the Atlantic Ocean. The colder air with which it now intermingles reduces the temperature with a corresponding reduction of its power of holding moisture, and so a precipitation of rain results. When warm air impinges upon cold mountain ranges, it is no longer capable

of retaining its moisture. This accounts for the excessive rainfall which these parts usually experience. Afforestation, owing to the chilling effect caused by evaporation, produces the same phenomenon.

When an atmosphere is saturated with moisture its "relative humidity" is 100%. **Relative humidity** may be defined as the percentage amount of moisture in the air, regarding saturation as 100. **Absolute humidity** is the actual weight of moisture present in a cubic foot of air. The **dew-point** is the temperature at which the air becomes saturated with moisture. A cubic foot of air at 32° F. is absolutely saturated when it contains 2·13 grains of moisture. Its relative humidity therefore is 100%, its absolute humidity 2·13 grains, and its dew-point 32° F.

If the temperature of air is raised, its power of absorbing moisture is increased. In other words, its relative humidity is reduced, but its absolute humidity remains the same. If the temperature was raised to that degree at which 4·26 grains of moisture would have to be present per cubic foot of air in order to cause saturation, its relative humidity would drop to 50%, as it now contains only half the amount of moisture it could contain. From this it must follow that an atmosphere feels moist, not so much on account of the amount of moisture it holds, but because its temperature is such that the air is near its saturation point. Therefore the greater the difference between the temperature of the air and its dew-point, the lower the relative humidity, and the greater its drying power. The percentage **drying power** then is the difference between 100 and the relative humidity.

As night approaches, the temperature of the air falls, and its saturation point is gradually reached. If the drop in the temperature is sufficiently great, the air arrives at a supersaturated condition, and dew therefore is deposited. If the temperature of this super-saturated condition is below 32° F., the vapour of the air must have been subjected to a freezing temperature, and therefore frozen vapour or frost is formed.

It is believed that the condensation of moisture must take place on solid particles which float in the air. Each mote acts as a nucleus for the moisture. This condition in a quiescent atmosphere causes a mist or fog. If the moisture is in excess, a wet fog results. In large manufacturing towns the solid carbon particles which have been discharged into the atmosphere act as nuclei, and cause the characteristic black fog. The pungency which usually accompanies this type of fog is due to the sulphurous acid present in the products of imperfectly combusted fuel.

The **meteorological stations** in the United Kingdom are divided into five classes—

1. Stations of the first order, or self-recording observatories.

Here all the principal meteorological phenomena are recorded continuously by means of self-registering instruments. Such data as pressure, temperature, wind, sunshine, and rain are autographically collected, with eye observations as to the condition of the sky, as, for example, the form, amount, and movement of clouds.

2. Stations of the second order, or normal climatological stations. At these observatories the pressure, temperature (dry-bulb and wet-bulb), wind, amount of cloud are taken twice daily, at 9 a.m. and 9 p.m., with the daily rainfall, maximum and minimum temperatures, and general remarks on the weather.

3. Stations of the third order, or auxiliary climatological stations. The records taken here are similar in kind to those at the normal climatological station, but are either less full or taken only once daily.

4. Telegraphic reporting stations. Certain eye observations are made at hours determined by the telegraphic system. In some cases these are supplemented by a continuous record of the barometric pressure.

5. Anemograph stations.—These are furnished with instruments which record continuously the velocity, or force, and direction of the wind. As a rule, no other condition is observed.

The thermometers used in the above-mentioned stations are: ordinary thermometers, self-recording thermometers, maximum and minimum thermometers, and radiation thermometers. They are periodically tested against a standard thermometer, which has been made with every care and precaution, in order to secure great accuracy. Mercury should be used in its construction, as mercury has many advantages over all other liquids for thermometric purposes. It expands equally at different temperatures, its freezing-point is low (— 40° F.), it has a high boiling-point (675° F.), it is a good conductor of heat, it has a low specific heat value, it is a pure liquid which does not wet the glass, and it has a low vapour pressure. Maximum thermometers are usually made with mercury, on account of its high boiling-point. On the other hand, minimum thermometers are constructed of alcohol, as no meteorological condition has ever produced a temperature at which alcohol freezes. In addition to this advantage, alcohol permits of the index, which is used in minimum thermometers, being easily seen.

The ordinary thermometer is made in four steps—

1. **Calibration.**—The accuracy of a thermometer must obviously depend upon the uniformity of the calibre of the tube. This is accomplished by introducing a "pencil" of mercury into the bore, and measuring its length at different positions in the tube. If it varies the tube must be rejected, and the process repeated until a tube is found the bore of which is absolutely uniform.

2. **Filling.**—The tube and bulb are warmed to expel some of the air. A funnel which has been fitted to the top of the tube is now filled with mercury. As the bulb cools a partial vacuum is formed, which allows some of the mercury to slip down the tube into the bulb. This warming and cooling is repeated until the bulb is filled with mercury. The funnel is now disconnected, the bulb once again heated until the mercury overflows the tube, which is at once sealed up by fusing the top of it in a bunsen burner.

3. **Curing.**—Owing to the length of time glass takes when once heated to assume a permanent shape, the instrument should not be graduated for many months, and, in the case of a standard thermometer, for some years. This "curing" obviates the error known as "displacement of zero."

4. **Graduation.**—Two fixed points must first of all be determined. The thermometer is plunged into melting ice (note that melting ice and freezing water need not have the same temperature; water kept very still has a freezing-point below 0° C.), and when the mercury is steady a mark is made on the stem at the mercury level. This mark is called 0° or 32°, according to whether a Centigrade or Fahrenheit thermometer is required. The tube is next completely immersed in steam from water boiling at a pressure of 760 mm. or 29·9 inches of mercury. The stem is again marked at the top of the mercurial column. This mark is called 100° if a Centigrade thermometer is in course of construction, or 212° in the case of a Fahrenheit thermometer. The distance between the two marks is now subdivided into 100 or 180 equal divisions, and from these the stem below the freezing-point and above the boiling-point is also graduated.

Since 212° F. equals 100° C., and 32° F. equals 0° C., it follows that C. is to F. as 100 is to 180 (212–32), or as 5 is to 9.

That is—
$$\frac{\text{Centigrade}}{5} = \frac{\text{Fahrenheit} - 32}{9}$$
$$\therefore \qquad C = \frac{5}{9} \times (F. - 32)$$
and
$$F. = \left(\frac{9}{5} C.\right) + 32.$$

Examples—

1. Convert 60° F. to C.
$$C. = \frac{5}{9}(60-32) = 15{\cdot}5°.$$

2. Convert − 40° C. to F.
$$F. = \left(\frac{9}{5} - 40\right) + 32$$
$$= -72 + 32$$
$$= -40°.$$

It will be observed that at a temperature of $-40°$ the thermometers coincide. The following is a proof of this—

Let F. and C. be called x.

Then— $$x = \frac{5}{9}(x - 32)$$

$$\therefore \quad 9x = 5x - 160$$

or— $$9x - 5x = -160$$

$$\therefore \quad 4x = -160$$

$$\therefore \quad x = -\frac{160}{4} = -40.$$

Maximum and minimum thermometers are so constructed that the highest and lowest temperatures to which they have been exposed may be recorded. In the best pattern of maximum thermometer a constriction is placed in the stem near the bulb. This allows the mercury to enter the stem from the bulb when the temperature is raised, but does not permit the mercury to re-enter the bulb when the temperature falls, consequently a maximum reading is obtained. Reset the instrument by shaking it bulb downwards as with the ordinary clinical thermometer. In the case of Rutherford's minimum thermometer, an index is immersed in the alcohol. When a reading is to be taken, the instrument is placed horizontally with the index as far from the bulb as possible. With a fall of temperature the contracting alcohol carries the index back, with a rise of temperature the alcohol flows past the index without moving it. The end of the index further from the bulb therefore registers the minimum temperature. By means of a magnet the index may be reset. These thermometers (along with the wet- and dry-bulb hygrometer) are placed in the shade. For that purpose a louvred box, with legs 4 feet long, known as Stevenson's screen, may be employed. The louvres allow a free access of air, at the same time excluding sunshine and rain. The door, which should be kept open, should face the north.

The **solar radiation thermometer** consists of an ordinary maximum instrument with its bulb blackened to absorb the heat of the sun's rays. It is encased in a glass tube from which air and moisture have been exhausted in order to reduce the effects of cold winds and to protect the bulb from rain. It should be placed about 5 feet above the ground, freely exposed to the sun, with its bulb directed towards the south-east.

The **terrestrial radiation thermometer** is a large bulbed instrument placed about 2 inches above the ground. It records a minimum temperature. The difference between its reading and that of the ordinary shade minimum thermometer represents the degree of terrestrial radiation.

Six's thermometer registers both the maximum and minimum

temperatures, but owing to its inaccuracy it cannot be regarded as a scientific instrument, and so it does not form a part of the equipment of a meteorological station.

The **thermograph,** or self-recording thermometer, is so constructed as to record its own reading, independent of any observer. In the common form, bands of metal fixed at one end respond by the ordinary processes of expansion and contraction to alterations of temperature. By a series of levers, the movements of these bands raise or lower a pen, which records the temperature on a paper surrounding a clockwork cylinder. The paper is divided by vertical lines to represent days and hours, and by horizontal lines to represent degrees of temperature. As the cylinder takes a week to revolve, a continuous record of the temperature for a week is obtained. Periodically the instrument should be corrected against a standard thermometer by means of a screw provided for the purpose.

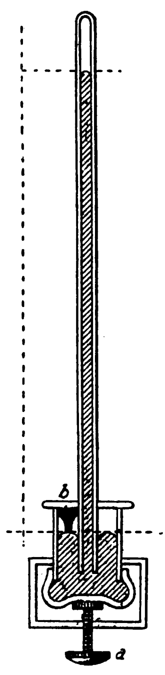

FIG. 18.

Barometers.—A barometer is an instrument for measuring the weight or pressure of the atmosphere. On an average the air presses with a weight of about 14·7 lbs. per square inch of the earth's surface. If our atmosphere could be supplanted by a sea of mercury 760 mm. in depth, the same pressure would be exerted. It is for this reason that we say, under normal conditions the pressure of the atmosphere is equal to 760 mm. or 29·9 inches of mercury. To construct a barometer a glass tube 33 inches long is filled with boiled mercury (to expel all air). The tube is then closed with the thumb, inverted, and the lower end plunged into a cistern containing more mercury. When the thumb is removed some of the mercury will fall into the cistern, but the column which remains suspended in the tube will represent the pressure of the air at the time. The vacant space left at the top of the tube is known as the Torricellian vacuum. If the air increases in pressure, the level of the mercury in the cistern is compressed, and consequently the mercury in the tube ascends. The column therefore has been extended, not only by the amount the mercury has ascended in the tube, but also by that degree of fall which has occurred in the cistern. With Fortin's standard barometer (Fig. 18), the one usually employed, to compensate for this " error of capacity," and in order to standardise all readings, the leather base of the cistern can be raised or lowered by means of a screw *a* until the level of the mercury just touches the tip of the ivory

peg *b*. The ivory peg is known as the fiducial point, and its tip is zero of the scale, consequently this adjustment allows an accurate reading to be made.

The barometer scale is marked off in inches, each inch being subdivided into twenty equal divisions. The instrument is read to the nearest division below the level of the mercury in the tube. The vernier is then so adjusted that its base is tangential with the top of the convexity of the mercury. Now note the point at which a division on the vernier exactly corresponds with one on the main scale. Count from below upwards how many of the twenty-five vernier divisions have to be passed before this point is reached. Multiply this number by 0·002 and add the product to the first reading on the main scale. The answer gives the pressure of the air in terms of inches of mercury. The main scale is also divided into centimetres and millimetres. The vernier is not required when the metric system is employed.

The 0·002 is a constant, and is obtained as follows—

Twenty-five vernier divisions equal in total length twenty-four scale divisions. As 1 scale division $= 0·05$ of an inch, $24 = 24 \times 0·05 = 1·2$ inches.

$\therefore$ 25 vernier divisions $= 1·2$ inches.
$\therefore$ 1 vernier division $= \frac{1}{25}$ of 1·2 inches $= 0·048$ of an inch.
$\therefore$ 1 scale division $-$ 1 vernier division $= 0·05 - 0·048 = 0·002$.

In order to get an accurate barometric reading, corrections have to be made for the following errors—

(1) Temperature; (2) altitude; (3) capillarity; (4) index; (5) capacity.

1. An allowance must be made for the expansion or contraction of the mercury due to differences of temperature. The brass scale is also similarly affected. Corrections are made by formulæ.

2. The pressure varies with the altitude. It is near enough for most practical purposes to allow a fall of 1 inch for every 1000 feet of ascent. It is on this principle that heights are estimated by barometric readings.

3 and 4. These vary with each instrument, and are supplied with all certificated instruments.

5. The correction for this error has been described.

In the **Kew barometer** the base of the cistern is fixed and there is no fiducial point. The error of capacity is obviated by making the "inches" on the scale shorter by 0·04 of an inch. The relationship between the size of the tube and that of the cistern is such, that a rise of 0·96 of an inch of the mercury in the tube is accompanied by a fall of 0·04 of an inch of the mercury in the cistern. The column therefore is really longer by 1 inch.

Mercury is used for barometer construction because of the advantages it possesses in not wetting the tube, and in the shortness of the column in consequence of its high specific gravity. If water were used a tube about 36 feet long would have to be employed. This would allow smaller variations of atmospheric pressure to be more easily observed; but as water freezes at a comparatively high temperature it is practically unavailable. Glycerine might be selected, as it does not freeze at any terrestrial temperature. As the specific gravity of glycerine is only about one-tenth that of mercury, it is obvious that it would magnify ten times the reading of a mercurial barometer. Its drawback is its hygroscopic property, but this can be removed by covering that portion which is in the cistern with paraffin oil.

The aneroid barometer, as the name implies, contains no fluid. It consists of a small hermetically sealed German-silver box, exhausted of air. Owing to the elasticity of the metal, the sides tend to collapse with an increase of atmospheric pressure. A spring, however, is so attached that it acts in opposition. With any variation of pressure therefore the spring is either compressed or relaxed. The movements of the spring are translated by a pointer on a dial. The common form of barograph is simply an aneroid barometer. The movements of the vacuum chamber, which in this case is made of concentric rings to increase elasticity, are recorded by means of a pen on a revolving drum, on precisely the same principle as the self-registering thermometer.

Hygrometers.—Of these instruments there are two kinds, direct and indirect. Both determine the dew-point, the former by noting the temperature at which the dew is actually deposited, and the latter by means of a formula. Daniel's and Dine's hygrometers are examples of the direct type, and Mason's hygrometer, or the wet- and dry-bulb thermometers, is the only one classed as indirect.

Daniels' is a closed glass tube in the shape of an inverted U with bulbous extremities, one bulb usually being lower than the other. The tube is exhausted of air, but contains ether vapour, as the lower bulb is partially filled with ether. This bulb is surrounded by a golden band, and contains a thermometer. To make an observation the upper bulb is covered with a muslin bag, or other suitable material. On this ether is carefully dropped till the moisture of the air is seen to dim the golden band. At the first evidence of this the temperature is noted. The application of the ether is then discontinued, and the temperature again taken when the moisture has disappeared and the golden band assumes its normal condition. The mean of the two readings is the dew-point.

With Dine's hygrometer ice-cold water is made to pass through a chamber roofed with green glass, until a deposition of moisture occurs on the external side of the glass. A ther-

mometer attached to the instrument records the temperature. The passage of the water is stopped, and the temperature again noted when the moisture disappears. The mean of the two is the dew-point.

Mason's hygrometer is the one in common use. It consists of two mercurial thermometers, the bulb of one being surrounded by strands of cotton, the free ends of which are immersed in a vessel containing distilled or rain water. By capillary attraction the bulb of this thermometer is kept wet. Owing to the chilling effect of the evaporation of the water, the reading of the wet-bulb thermometer is almost invariably lower than that of the dry-bulb. The greater the difference between the two temperatures the drier the air, and conversely the more closely they approximate the wetter the air. The dew-point, with the aid of Glaisher's hygrometrical tables, is calculated from the following formula—

Dew-point = D.B.T. − {(D.B.T. − W.B.T.) × F}
D.B.T. = dry-bulb temperature
W.B.T. = wet-bulb temperature
F. = the factor corresponding with the dry-bulb temperature, as obtained from the tables.

FORCE OF VAPOUR TABLE

Temperature F.	Force of Vapour.	Temperature F.	Force of Vapour.	Temperature F.	Force of Vapour.
35·0	0·204	45·0	0·299	55·0	0·433
35·5	0·208	45·5	0·305	55·5	0·441
36·0	0·212	46·0	0·311	56·0	0·449
36·5	0·216	46·5	0·317	56·5	0·457
37·0	0·22	47·0	0·323	57·0	0·465
37·5	0·225	47·5	0·329	57·5	0·473
38·0	0·229	48·0	0·335	58·0	0·482
38·5	0·233	48·5	0·342	58·5	0·491
39·0	0·238	49·0	0·348	59·0	0·50
39·5	0·242	49·5	0·355	59·5	0·509
40·0	0·247	50·0	0·361	60·0	0·518
40·5	0·252	50·5	0·367	60·5	0·528
41·0	0·257	51·0	0·374	61·0	0·537
41·5	0·262	51·5	0·381	61·5	0·546
42·0	0·267	52·0	0·388	62·0	0·556
42·5	0·272	52·5	0·396	62·5	0·566
43·0	0·277	53·0	0·403	63·0	0·576
43·5	0·283	53·5	0·41	63·5	0·586
44·0	0·288	54·0	0·418	64·0	0·596
44·5	0·294	54·5	0·425	64·5	0·607

The relative humidity is calculated by multiplying the weight of moisture per cubic foot of saturated air at the dew-point temperature by 100, and dividing by the weight of moisture per

cubic foot of saturated air at the dry-bulb temperature. It may also be expressed as a formula, thus—

$$\text{R.H.} = \frac{\text{Force of vapour at D.P.T.} \times 100}{\text{Force of vapour at D.B.T.}}$$

D.P.T. = dew-point temperature

D.B.T. = dry-bulb ,,

The vapour force factors are obtained from Glaisher's tables. Each factor is the amount of mercury in inches that could be supported by the pressure of the vapour in a cubic foot of saturated air at that temperature.

Rainfall is measured by means of a gauge, the diameter of which is usually 8 inches. The receiving surface is funnel-shaped, with a knife-edge rim, in order to cut a rain-drop and so prevent loss or excess. The rim also bends inwards. This obviates loss which might be occasioned by splashing when the rain is being driven in an oblique direction. The bottom of the funnel is turned upwards so as to form a water seal. The object of this is to reduce evaporation of the water which has collected in the main receptacle. It need hardly be said that the gauge must be placed in the open air, as far removed from buildings and trees as possible, and firmly embedded with not less than 1 foot of its height above the ground, to preclude the possibility of heavy rain splashing into the gauge. The water which has been caught during any twenty-four hours is measured by pouring it into a glass cylinder, graduated to represent inches and parts of an inch of rainfall. The smallest amount that can be measured is one-hundredth of an inch. As the area of the receiving surface of the gauge is 50·2 square inches, it is obvious that a 1-inch rainfall means an amount of water equal to 50·2 cubic inches or 29 oz. Hence, if that quantity of water be poured into a glass cylinder and a mark made thereon to correspond with the level at which the water stands, this mark represents 1 inch of rainfall. The sub-divisions can be made in a like manner.

The velocity of the wind may be determined by means of **Robinson's anemometer.** This instrument consists of four hollow hemi-spherical vanes which always revolve in the same direction. Attached to the vanes is a vertical spindle which transmits the motion through gears to a dial, on which the actual distance travelled by the wind is recorded. Thus the velocity of the wind may be returned as so many miles over any fixed period of time. Owing to friction and to the difference of wind pressure on the concave and convex sides of the cups, the dial would register only about one-third of the true velocity, if this fact was not compensated for by means of the mechanism.

The force of the wind is measured as pounds pressure per square foot of surface.

$$P = V^2 \times 0{\cdot}005$$

where P = pressure and
V = velocity in miles per hour.

If the force is known, then velocity—

$$= \sqrt{200P}.$$

With " Beaufort's scale " the wind force is stated as a number, thus—

Beaufort scale number.	Corresponding wind.	Velocity as miles per hour.
0	Calm	under 1
1 to 3	Light breeze	1 to 12
4 to 5	Moderate wind	13 to 24
6 to 7	Strong wind	25 to 38
8 to 9	Gale	39 to 54
10 to 11	Storm	55 to 75
12	Hurricane	over 75

A record of the sunshine may be taken by means of **Campbell-Stokes' sunshine recorder.** The rays of the sun are concentrated by a crystal globe, 4 inches in diameter, on a piece of cardboard situated in an arc at a distance from the globe corresponding with the focal point of the rays. In this way the cardboard is charred, and, as the cardboard is divided into spaces to represent hours of the day, the duration of sunshine can be reckoned from the length of the charred line. It must be placed in a fully-exposed position facing due south, and the arc supporting the recording card must incline to the horizon at an angle equal to the latitude of the place.

INFLUENCE OF CLIMATE ON HEALTH

Warm Climates (35° N.–35° S.).—There is a special liability to heat-stroke; and diseases such as malaria, cholera, dysentery, yellow fever, and small-pox are prevalent. The temperature of the air has a very definite influence on the development of certain forms of parasitic and bacterial life. Thus it is only in countries where favourable conditions of temperature are met with that malaria is truly endemic. In hot, dry climates the skin acts freely and the urinary secretion is diminished, and when heat and relative humidity are both excessive a certain amount of nervous depression is produced. Heat-stroke is apparently the result of auto-intoxication, due to heat retention in the body and the accumulation of toxic material which has a special action on the nerve-cells. Alcoholism predisposes, and the condition is commoner when relative humidity is high.

"Heat exhaustion" is the mildest form, then "heat prostration," which is an afebrile condition accompanied frequently by fainting attacks. "Heat stroke" proper is more serious. There is usually fever, and three types have been described—asphyxial, paralytic, and delirious. In the tropics stokers may suffer from "heat cramp." Exposure to the glare of the sun is damaging to weak eyes and may produce actual sunstroke. It is frequently asserted that, provided sanitary measures are adequate and personal hygiene is cultivated, Europeans can live as healthily in the tropics as in temperate climates.

Temperate climates (35–50° N. or S.) have a mean temperature of 60° F. The diseases most prevalent are rheumatism, affections of the respiratory organs, especially pneumonia and pulmonary tuberculosis, and the ordinary exanthemata.

Cold Climates.—In ice-bound regions eye trouble from the reflection of light from the snow is common. Scurvy, of course, may occur if antiscorbutic measures are not adopted. Frostbite is directly attributable to cold. As a rule appetite is quickened and muscular activity stimulated. Skin secretion diminishes and urine increases in amount.

Mountain Climates.—Here respiratory movements are increased and the clear, dry air usually exercises a tonic effect on the system. Early phthisis, anæmia, and rheumatism benefit by such conditions, but bronchitis and any acute disease are contra-indications. The movement of the air is great in such situations, and individuals indulge in more physical exercise, thereby benefiting their health. Owing to the rarification and dryness of the air radiant heat from the sun is rapidly absorbed by the earth during the day and is as rapidly given up at night. Hence night temperatures are apt to be low. The physiological effects of altitude due to lessened pressure do not usually make themselves noticed below 6000 or 7000 feet. Above these heights the pulse-rate and respirations increase. Evaporation from the skin is quickened and urinary secretion diminished. As pressure diminishes the limbs begin to feel heavy, and bleeding may occur from mucous membranes. An oxygen content below about 7% produces unconsciousness.

Maritime Climates.—Coastal areas and islands have a more equable climate than interiors, on account of the specific heat of the sea being greater than that of the land, and also on account of the more general rainfall. Rheumatism and respiratory diseases are more common in such districts.

PHYSICS AND CALCULATIONS

Conduction is the transference of heat from particle to particle with no change in their relative positions. Solids get hot by conduction.

Convection is the transference of heat by moving particles. Liquids and gases are heated by convection. The heated, and therefore lighter, particles ascend. The colder ones descend, and in their turn get heated.

Radiation is the transmission of heat by means of waves, which warm the articles they strike, but not the medium through which they pass.

Cohesion is the attraction which molecules have for each other in the same body.

Adhesion is the attraction which they have for each other in different substances.

Charles' Law.—Gases expand or contract $\frac{1}{273}$ of their volume for each degree rise or fall from 0° Centigrade, the pressure remaining constant. That is, the coefficient of expansion is $\frac{1}{273}$ of its volume at 0° C., or $\frac{1}{491}$ for each degree Fahrenheit from 32°.

Let it be required to find what 1000 volumes at 10° C. will become at 30° C.

We must first of all find what the 1000 volumes will become at 0° C.

$$1 \text{ volume at } 0^\circ \text{ C. becomes } 1 + \frac{10}{273} \text{ volumes at } 10^\circ \text{ C.}$$

$$\therefore 1000 \text{ volumes at } 0^\circ \text{ become } 1000 \times \left(1 + \frac{10}{273}\right) \text{ at } 10^\circ \text{ C.}$$

or

$$1000 \text{ volumes at } 10^\circ \text{ become } \frac{1000}{1 + \frac{10}{273}} \text{ at } 0^\circ \text{ C.}$$

$$= 964 \text{ (nearly).}$$

$$\therefore \quad 1000 \text{ volumes at } 10^\circ \text{ C. become } 964 \text{ at } 0^\circ \text{ C.}$$

$$\text{Now } 1 \text{ volume at } 0^\circ \text{ C. becomes } 1 + \frac{30}{273} \text{ volumes at } 30^\circ \text{ C.}$$

$$\therefore \quad 964 \text{ volumes at } 0^\circ \text{ become } 964 \times \left(1 + \frac{30}{273}\right) \text{ at } 30^\circ \text{ C.}$$

$$= 1070 \text{ (nearly).}$$

$$\therefore 1000 \text{ volumes at } 10^\circ \text{ C. become } 1070 \text{ volumes at } 30^\circ \text{ C.}$$

From the above it is obvious that 1 volume at 0° C. becomes $1 - \frac{1}{273}$ at -1° C., and, therefore, if a temperature of -273° C. was reached the gas would have shrunk to nothing. As a matter of fact, the gas would cease to be a gas before such a temperature was reached. For this reason -273° C. is called the absolute zero, and any degree above that, the absolute temperature. Consequently 0° C. becomes 273° absolute. Therefore Charles' Law might have been stated: The volume of a gas varies directly

as the absolute temperature. This will simplify the example given above very considerably.

The temperatures given were 10° C. and 30° C., their absolute temperatures are 283° and 303° respectively. Therefore the 1000 volumes must increase by the same ratio as 303° is to 283°.

$$i.e. \qquad \frac{1000 \times 303}{283} = 1070 \text{ (nearly)}.$$

The same answer as before.

$$\therefore \qquad R.V. = \frac{G.V. \times (273 + R.T.)}{273 + G.T.}$$

R.V. = required volume
G.V. = given volume
R.T. = required temperature
G.T. = given temperature

Boyle's Law.—The volume of any gas varies inversely as the pressure, the temperature being constant. That is, if the pressure is doubled, the volume is halved.

∴ 1000 volumes at 740 mm. of mercury pressure become at 760 mm.—

$$\frac{1000 \times 740}{760} = 973 \text{ (nearly)}.$$

Graham's Law.—The rate at which a gas diffuses is inversely proportional to the square root of its relative density. The relative density (specific gravity) of an element is its atomic weight, and that of a compound, half its molecular weight. The relative densities of oxygen and hydrogen are 16 and 1 respectively, the rates at which they diffuse therefore are $4(\sqrt{16})$, and $1(\sqrt{1})$. That is, oxygen diffuses four times more slowly than hydrogen.

Inasmuch as the density of hydrogen is 1, and 1 litre weighs 0·08958 gram, the weight of a litre of any gas can be found, if its relative density is known.

The relative density of carbon dioxide is 22. Therefore 1 litre of CO_2 weighs $22 \times 0{\cdot}08958$ grams. This may be stated in another way. From the above it can be calculated that 11·2 litres of hydrogen weigh 1 gram, and therefore 11·2 litres of CO_2 must weigh 22 grams, and 11·2 litres of oxygen 16 grams. Therefore 11·2 litres of any gas weigh in grams its relative density. To continue the example, 11·2 litres of dry air weigh 14·47 grams, and the same volume of aqueous vapour $9\left(\frac{18}{2}\right)$ grams. From this it must follow that dry air weighs more than a mixture of air and moisture. As the pressure is directly proportional to the weight, moist air is not capable of supporting the same column of mercury as dry air, other things being equal, and therefore the barometer falls when rain is imminent.

Specific heat is the amount of heat required to raise 1 gram of any substance through 1° C., as compared with the amount required to raise 1 gram of water 1° C. Hence it is a relative expression, taking water as the standard. It may be determined by a method of mixtures.

Three grams of mercury at 100° C. are mixed with 1 gram of water at 0° C. The resulting temperature is 9° C. What is the specific heat of mercury ?

It is obvious that the heat gained by the water is lost by the mercury.

$\therefore$ 3 grams of mercury lost $100° - 9° = 91°$ C. in raising 1 gram of water through 9° C.

$\therefore 3 \times 91 = 1 \times 9.$

But as each has a specific heat value, each side of the equation must be multiplied by that value.

$\therefore 3 \times 91 \times$ specific heat of mercury $= 1 \times 9 \times$ specific heat of water.

The specific heat of water is taken as 1—

$$\therefore \quad 273 \times \text{specific heat of mercury} = 9.$$

$$\therefore \quad \frac{9}{273} = \frac{1}{30} = \text{specific heat of mercury.}$$

Now $9 =$ weight of water (1 gram) $\times$ (resulting temperature $-$ the original temperature of the water).

And $273 =$ weight of mercury (3 grams) $\times$ (original temperature of mercury $-$ resulting temperature).

If

$W =$ weight of water.
$T =$ the temperature of the water
$w =$ weight of the substance
$t =$ the temperature of the substance
R.T. $=$ resulting temperature

$$\text{Specific heat} = \frac{W \times (\text{R.T.} - T)}{w \times (t - \text{R.T.})}.$$

If an exact determination is required the specific heat of the material which contains the water must be taken into account.

The amount of heat a body contains is the product of its mass, temperature, and specific heat. Therefore, if we know the weight of ice melted by a body of known weight and temperature, its specific heat can be calculated from the following equation—

$$\text{M.T.S.} = 80\ \text{W}.$$

M $=$ weight of the body
T $=$ temperature of the body
S $=$ specific heat " "
80 $=$ latent heat of water
W $=$ weight of ice melted.

$$\therefore \quad \text{specific heat} = \frac{80\text{W}}{\text{M.T.}}.$$

Latent heat is the amount of heat given out or absorbed by a body in the act of changing its state.

If 1 lb. of water at 100° C. be mixed with 1 lb. at 0° C., the resulting temperature will be 50° C. But if 1 lb. of water at 100° C. is mixed with 1 lb. of ice at 0°, the resulting temperature will be 10° C. This implies that the water lost 90° C. in melting the ice and in raising its temperature 10° C. The actual amount of heat, therefore, required just to melt the ice is 80° C.

The latent heat of steam is determined by a calorimeter. Into a known weight of water at a known temperature steam is made to pass. The steam in condensing will raise the temperature of the water and increase its weight. If these data are known the latent of the steam can be calculated. Supposing the weight and temperature of water at the commencement of the experiment are 9 oz. and 15° C., and at the end 10 oz. and 77° C., then 1 oz. of steam has raised 9 oz. of water from 15° C. to 77° C.

$\therefore$ 1 oz. of steam lost 23° C. (100–77) in raising 9 oz. of water 62° C. (77–15).

$\therefore$ 23° C. + latent heat of steam $= 9 \times 62 = 558°$ C.

$\therefore$ latent heat $= 558 - 23 = 535°$ C.

This is approximately the latent heat of steam.

If ice is melted, and the resultant water is converted to steam, the following phenomena take place. Eighty units of heat are first absorbed in converting the ice to water at 0° C. The water decreases in volume as the temperature rises, until 4° C. is reached, when the water is at its point of maximum density (hence ice floats). Then it expands as the temperature is further raised to 100° C., when it absorbs 537° C. in becoming steam.

Steam is said to be "**saturated**" when at the same temperature as the water from which it was evolved. If heat is applied to the steam it becomes "**superheated,**" that is, it has a higher temperature than the water. It must not be deduced from this that superheated steam has a higher temperature than saturated steam. The boiling-point of water depends upon the pressure, consequently the temperature of steam generated from water subjected to a greater pressure, may be much higher than ordinary steam produced under normal conditions but subsequently superheated.

Specific gravity is the ratio of the weight of a volume of any substance to the weight of the same volume of a standard substance, the temperature and pressure being constant. It is a number, therefore, not a weight. The specific gravity of a liquid may be taken by means of a specific gravity bottle, water at 4° C. being the standard.

As far as solids are concerned, these may be placed into four groups.

A. Those heavier than water.
B. Those with the same weight as water.
C. Those lighter than water.
D. Those soluble in water—sugar, for example.

A. The substance is first weighed in air, and secondly when suspended in water.

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight lost in water}}.$$

This must be so, as the volume of the water displaced equals the volume of the substance immersed, and the weight of water displaced is equal to the weight lost by the substance.

B. The specific gravity of these bodies must be one.

C. A solid lighter than water floats. Its specific gravity is the fraction of itself immersed. This fraction may be calculated by means of a glass cylinder provided with a spout. The cylinder is filled with water until some flows out of the spout. Then the solid is lowered gently into the water, the amount overflowing being caught in a vessel and measured. Suppose 15 c.c. are collected. The solid is now pushed down until the whole of it is submerged, the amount of water displaced again being measured. Let the total amount be 20 c.c. Then $\frac{15}{20}$ of its volume were in the first instance below the surface of the water. Therefore its specific gravity is 0·75.

D. The substance is weighed in air, and then in a liquid which will not dissolve it. Its specific gravity is equal to its weight in air multiplied by the specific gravity of the liquid in which it was weighed, and divided by the weight it lost in that liquid.

The Expansion of Solids and Liquids.—As in the case of gases, solids and liquids have a coefficient of expansion. If a solid whose length is 1 be raised in temperature from $0 - 1°$ C., its new length is $1 +$ its coefficient of expansion. If the temperature is increased to 50° C. the length becomes $1 + (50 \times \text{the coefficient})$, $\therefore$ the length of a rod at 50° C. equals its length at $0° \text{ C.} \times \{1 + (50 \times \text{Coef.})\}$.

For example, say the length at 0° was 3 inches and at 50° C. was 3·000568 inches, then $3{\cdot}000568 = 3 \times \{1 + (50 \times \text{Coef.})\}$

$$\therefore \qquad \frac{3{\cdot}000568}{3} = 1 + (50 \times \text{Coef.})$$

$$\text{that is} \qquad 1{\cdot}0001893 = 1 + (50 \times \text{Coef.})$$

$$\therefore \qquad 1{\cdot}0001893 - 1 = 50 \times \text{Coef.}$$

$$\text{or} \qquad \frac{0{\cdot}0001893}{50} = \text{Coef.} = 0{\cdot}0000378 \text{ inch.}$$

This represents its coefficient of linear expansion. If this reasoning be continued and applied to a square, it is obvious

that if the coefficient be called x, the area of a square at 1° C. will be $(1 + x) \times (1 + x)$, whose area was 1×1 at 0° C.

$$(1 + x)^2 = 1 + 2x + x.^2$$

As x^2 is a negligible quantity, the square expansion may be regarded as being twice the linear expansion. In precisely the same way, the cubical expansion is practically three times the linear.

To find the expansion of a liquid, the cubical expansion of the vessel which contains that liquid must be known. If a flask, with a perforated cork taking a long tube, be filled with water up to a point somewhere in the tube, and heat is applied, the level of the water first of all falls, on account of the expansion of the flask. The difference between the original level of the water and the level to which it sinks must be equal to the cubical expansion of the material of which the flask is made. If the application of heat be continued, the level of the water will rise above the original mark.

If A = the original level,
B = reduced level,
C = raised or final level,
then A − B = cubical expansion of the vessel,
C − A = apparent expansion of the water,
C − B = real expansion of the water,

$\therefore$ the real expansion of a liquid is its apparent expansion + the cubical expansion of the vessel.

Siphons.—The explanation of the action of a siphon is one of atmospheric pressure. If the level of the liquid in the longer leg of the siphon corresponds with the level of the liquid in the vessel, the liquid is in a state of equilibrium, that is, the air pressure on each side has precisely the same volume of liquid to support, consequently the liquid remains stationary. If the outer leg is filled, then the additional volume of liquid which it contains flows out in order to re-establish the balance, other portions of the fluid now flow on to occupy the same position, and so the process is continued.

SEWER CALCULATIONS

Etelwein's Formula—

$$v = 55\sqrt{\text{H.M.D.} \times 2\text{F}}$$

v = velocity of flow in feet per minute.

F = fall of sewer in feet per mile.

H.M.D. = hydraulic mean depth. This equals the sectional area of the current of fluid divided by the wetted perimeter. In the case of circular sewers flowing full or half full, it is a quarter of the diameter.

Proof.—The sectional area of the fluid in a round sewer flowing full is the area of a circle or πr^2; the wetted perimeter is the circumference or $2\pi r$.

$$\therefore \qquad \text{H.M.D.} = \frac{\pi r^2}{2\pi r} = \frac{r}{2} \text{ or } \frac{D}{4}.$$

Example.—A circular sewer flowing half full has a diameter of 8 feet. The fall is 1 in 960. What is the velocity of the flow ?

$$v = 55\sqrt{\text{H.M.D.} \times 2F}$$
$$\text{H.M.D.} = \tfrac{1}{4} \text{ of } 8 = 2.$$
$$F = 1 \text{ foot in 960 feet or } 5{\cdot}5 \text{ feet in 1 mile.}$$
$$\therefore \quad v = 55\sqrt{2 \times 2 \times 5{\cdot}5}$$
$$v = 55 \times 4{\cdot}7 \text{ (nearly)}$$
$$\therefore \quad v \text{ per minute} = 258{\cdot}5 \text{ feet.}$$
$$\text{or} \qquad \frac{258{\cdot}5}{60} = 4{\cdot}3 \text{ feet per second.}$$

Quantity discharged = velocity × area of fluid, or Q = VS. Let it be required to find the amount of sewage discharged by this sewer in one hour.

Then 4·3 × half the area of a circle whose diameter is 8 feet, as the sewer is flowing half full, will equal the discharge in cubic feet per second.

That is—
$$4{\cdot}3 \times 3{\cdot}1416 \times 4^2 \div 2$$
$$(\pi = 3{\cdot}1416)$$
$$= 108$$

$$\therefore \quad 108 \times 3600 \text{ (the number of seconds in the hour)}$$
$$= 388{,}800 \text{ cubic feet per hour.}$$
$$\text{or} \qquad 388{,}800 \times 6{\cdot}23 \text{ (gallons per cubic foot)}$$
$$= 2{,}412{,}224 \text{ gallons discharged per hour.}$$

If the fall of a sewer is x and its velocity y, then if the fall be changed to z, the new velocity will be $y \times \frac{\sqrt{x}}{\sqrt{z}}$, that is to say, the velocities vary inversely as the square roots of the falls.

Example.—A sewer with a fall of 1 in 196 has a velocity of 3 feet per second. What would the velocity be if the fall was 1–400 ?

$$3 \times \frac{\sqrt{196}}{\sqrt{400}} = \frac{3 \times 14}{20}$$
$$= 2{\cdot}1 \text{ feet per second.}$$

The fall varies inversely as the squares of the velocities.

Example.—A sewer with a fall of 1–196 has a velocity of 3 feet per second. What fall would have to be given in order to reduce the velocity to 2·1 feet per second ?

$$\frac{196 \times 3^2}{2 \cdot 1^2} = \frac{196 \times 9}{4 \cdot 41} = 400$$

The new fall is 1–400.

This proves the first example.

If three drains converge to one common one, the area of this must equal the sum of the areas of the three, or its diameter must be the square root of the sum of the squares of the diameters of the three.

Example.—Three drains, 4 inches, 6 inches, and 8 inches in diameter respectively, converge and become one main drain. What is the diameter of this drain ?

$$\begin{aligned} \text{Area of 1st drain} &= 3 \cdot 1416 \times 2^2 = 12 \cdot 5664 \\ \text{,, ,, 2nd ,,} &= 3 \cdot 1416 \times 3^2 = 28 \cdot 2744 \\ \text{,, ,, 3rd ,,} &= 3 \cdot 1416 \times 4^2 = \underline{50 \cdot 2656} \\ \text{Area of main drain} &= \underline{\underline{91 \cdot 1064}} \end{aligned}$$

$$\begin{aligned} \text{As area} &= 3 \cdot 1416 \times r^2 \\ \text{then} \quad r &= \sqrt{\frac{\text{Area}}{3 \cdot 1416}} \\ \therefore \quad r \text{ of the main drain} &= \sqrt{\frac{91 \cdot 1064}{3 \cdot 1416}} \\ &= \sqrt{29} \\ &= 5 \cdot 38 \\ \therefore \quad 5 \cdot 38 \times 2 = 10 \cdot 76 &= \text{diameter of main drain} \\ \text{or} \quad \sqrt{4^2 + 6^2 + 8^2} &= \sqrt{116} \\ &= 10 \cdot 77. \end{aligned}$$

VENTILATION CALCULATIONS

Montgolfier's Formula—

$$V = 8\sqrt{\frac{(H - h) \times (T - t)}{491}} - F$$

V = velocity of air in feet per second.

$(H - h)$ = the difference between the heights of the levels of the incoming and outgoing air.

$(T - t)$ = the difference between the temperatures of the airs.

$\frac{1}{491}$ = the coefficient of expansion.

F = friction. This is an unknown quantity. It is usual, however, to account for it by assuming the true velocity to be $\frac{4}{5}$ of the velocity calculated.

Example.—At what rate will air enter an opening 4 feet above the floor, if provision is made for its escape 12 feet above the floor, the temperature inside being 60° F., and outside 50° F. ?

On applying these data we get—

$$V = 8\sqrt{\frac{(12-4) \times (60-50)}{491}} - F$$

$$= 8 \times \sqrt{\frac{80}{491}} - F$$

$$= 3{\cdot}2 - F.$$

$$\therefore \quad V = \frac{4}{5} \text{ of } 3{\cdot}2 = 2{\cdot}56 \text{ feet per second.}$$

If the area of the opening is known, then the amount of air entering can be determined from formula $Q = V \times S.A.$

De Chaumont's Formula.—

$$D = \frac{E}{R}$$

D = delivery of air in cubic feet per hour.
E = the total amount of CO_2 exhaled per hour.
R = respiratory impurity per cubic foot of air.

As the allowable respiratory impurity is 0·02%, R is 0·0002, unless another figure be specified.

Example.—How much fresh air must be supplied to a room of 5000 cubic feet capacity, in which four men and two women are engaged in doing ordinary work ?

$$E = (4 \times 1{\cdot}0) + (2 \times 0{\cdot}8). \quad \text{See Table.}$$

$$R = 0{\cdot}0002.$$

$$\therefore \quad D = \frac{5{\cdot}6}{0{\cdot}0002} = 28{,}000 \text{ cubic feet.}$$

It must be assumed that the air of the room was fresh at the commencement, therefore only 23,000 cubic feet of air are required for the first hour, but for all subsequent hours the 28,000 must be supplied.

TABLE OF "CO_2 EXHALED"

	Rest.	Ordinary work.	Hard work.
Man	0·7	1·0	1·5
Woman	0·6	0·8	1·2
Child	0·5		
Average	0·6		

These numbers are in cubic feet per hour.

Gas burners must not be included in the formula. To allow

for the air consumed by gas burning, an additional 1200 cubic feet of air must be provided for every cubic foot of gas burned.

Water Calculation.—Hawksley's Formula—

$$x = \frac{1000}{\sqrt{y}}$$

x = the number of days' water-supply to be stored,
y = the average rainfall for the three driest consecutive years.

If y is 25 inches, then $x = \frac{1000}{\sqrt{25}} = 200$ days.

Square Root.—Let it be required to find the square root of 292681. Expressing this as a decimal it would be written thus: 292681·00.

1. Mark off two figures at a time on both sides of the decimal point—29/26/81·00/.

To the left of the decimal point there are three periods, therefore the square root must be a three digit whole number.

2. What number which when multiplied by itself will go into 29, leaving the least remainder? Answer, 5.

Putting the 5 into both divisor and quotient, multiplying across, and subtracting, we get—

```
5)29/26/81·00/(5
  25
  —
   4
```

3. Bring down the next period, viz. 26. A new divisor is now required. This is obtained in two steps—

(*a*) Double the quotient, *i. e.* $2 \times 5 = 10$.
(*b*) This is found by trial. Let 6 be the chosen number.

Putting the 6 down with the 10 to make 106 and then multiplying 106 by 6 we get 636, which we see exceeds 426, so a fresh trial must be made. Let 4 be taken.

Therefore the divisor becomes 104, which when multiplied by 4 equals 416. This is the correct figure, as 5 is obviously too high.

```
          5)29/26/81·00/(54
            25
            —
104         426
            416
            ———
             10
```

4. Bring down the next period.

Find new divisor—

(*a*) Double 54 = 108.
(*b*) Repeated by trial calculation. One is the correct figure, as—

```
         5)29/26/81·00/(541
           25
           --
104         426
            416
            ---
1081        1081
            1081
            ----
            ....
```

$\therefore \quad \sqrt{292681} = 541.$

Required to find the square root of 552·25.
Marking off the figures as before we get—

5/52·25/.

What number which when multiplied by itself will go into 5, leaving the least remainder? Answer, 2.

```
2)5/52·25/(2
  4
  -
  1
```

Bring down the next period, viz. 52.
Find new divisor.

(*a*) Double 2 = 4.
(*b*) By trial 3 is found to be the number.

```
∴        2)5/52·25/(23
           4
           --
43         152
           129
           ---
            23
```

Having reached the decimal point, one is placed in the quotient.
Bring down the next period, viz. 25.
Find new divisor.

(*a*) Double 23 = 46.
(*b*) By trial 5 is the correct number.

```
∴           2)5/52·25/(23·5
              4
              —
      43      152
              129
              ———
     465       2325
               2325
               ————
               ....
               ════
```

∴ the $\sqrt{552{\cdot}25} = 23{\cdot}5$.

AREAS

Triangle.	Base × half the height. Where the length of each side only is given, then area $= \sqrt{S(s-a)(s-b)(s-c)}$ S = half the sum of the three sides, *a*, *b*, and *c*.
Square.	Square one of the sides.
Rhomboid and Rhombus.	Multiply the length of one side by the distance between that side and the one opposite.
Trapezoid.	Multiply the sum of the two parallel sides by the perpendicular distance between them, and halve the result.
Trapezium.	Divide into triangles, and find sum of these.
Regular polygon.	Multiply the length of one side by the perpendicular height to the centre, and by the number of sides, and halve the result.
Circle.	$D^2 \times 0{\cdot}7854$, or $R^2 \times 3{\cdot}1416$. Circumference $= D \times 3{\cdot}1416$.
Segment of a circle.	To $\frac{2}{3}$ of product of height and chord, add the cube of the height divided by twice the chord, or $\left(\frac{2}{3} \times H \times Ch\right) + \frac{H^3}{2\,Ch}$.
Ellipse.	Product of the two diameters $\times\ 0{\cdot}7854$.
Sphere.	Circumference × diameter.

CUBIC CAPACITIES

Cube or solid rectangle.	Length × height × breadth.
Pyramid or Cone.	Area of base × $\frac{1}{3}$ perpendicular height.
Dome.	Area of base × $\frac{2}{3}$ perpendicular height.
Cylinder.	Area of circular base × height.
Sphere.	$D^3 \times 0{\cdot}5236$.

TABLE OF FACTORS FOR CALCULATING EQUIVALENTS OF WEIGHT, VOLUME, LENGTH, ETC.

To convert	grams	to pounds	multiply by	0·0022
,,	,,	,, grains	,,	15·432
,,	,,	,, ounces	,,	0·0353
,,	grains	,, grams	,,	0·0648
,,	ounces	,, ,,	,,	28·349
,,	pounds	,, ,,	,,	453·715
,,	kilograms	,, pounds	,,	2·204
,,	,,	,, ounces	,,	35·3
,,	litres	,, gallons	,,	0·22
,,	,,	,, fluid ounces	,,	35·2
,,	,,	,, pints	,,	1·76
,,	,,	,, cubic feet	,,	0·0354
,,	,,	,, ,, inches	,,	61·027
,,	gallons	,, ,, feet	,,	0·1605
,,	,,	,, litres	,,	4·5371
,,	pints	,, ,,	,,	0·5679
,,	,,	,, cubic centimetres	,,	568·1818
,,	,,	,, ,, inches	,,	34·6592
,,	cubic metres	,, gallons	,,	220·4
,,	,,	,, pints	,,	1763·2
,,	,,	,, fluid ounces	,,	35264·0
,,	cubic feet	,, cubic metres	,,	0·0283
,,	,,	,, litres	,,	28·318
,,	,,	,, gallons	,,	6·2322
,,	fluid ounces	,, cubic inches	,,	1·7299
,,	,,	,, ,, centimetres	,,	28·35
,,	square feet	,, square metres	,,	0·0929
,,	,,	,, ,, yards	,,	0·111
,,	square metres	,, ,, feet	,,	10·7641
,,	inches	,, metres	,,	0·0254
,,	metres	,, inches	,,	39·37
,,	,,	,, feet	,,	3·28
,,	feet	,, miles	,,	0·000187
,,	,,	,, metres	,,	0·3048
,,	yards	,, miles	,,	0·00057
,,	,,	,, centimetres	,,	91·44
,,	centimetres	,, inches	,,	0·3937
,,	kilometres	,, miles	,,	1·6

SECTION XI

NOTES ON CHEMISTRY

WATER

Collection of Water Samples.—For chemical analysis water should be collected in a Winchester-quart bottle. First cleanse the bottle by rinsing with weak acid, and then wash thoroughly with good tap water. Before filling the bottle with the sample, rinse it once or twice with the water to be collected. The bottle should have its stopper carefully tied down and sealed, and should be labelled with the name of the collector, the date of the collection, and with an identification number. It is advisable to send the sample to the analyst in a special wicker basket as expeditiously as possible. It should be accompanied by a letter stating the reason for the analysis, the rainfall for the previous twenty-four hours, any possible sources of pollution, and, in the case of a well, the nature of the surrounding soil.

The water sample should be collected under the same conditions as it is drawn for drinking purposes. In a house take the sample from the lowest tap, so that water having run the greatest risk of pollution in the house will be secured. With a well, pump thoroughly for several minutes in order to sample as much of the drainage area as is likely to be drawn upon in the course of the day.

Water Analysis.—The following estimations form a complete sanitary analysis for most practical purposes.

Physical Characters.—Colour, smell, taste, lustre, clearness, suspended and deposited matter.

Reaction.

Wanklyn's Process for free and saline and albuminoid ammonias.

Tidy's Process for organic matter.

Winkler's Process for dissolved oxygen.

Nitrites, qualitative and quantitative.

Nitrates, ,, ,, ,,

Hardness, total, permanent and temporary.

Solids, total, volatile and non-volatile.

Poisonous metals, qualitative and quantitative.

Sulphates, qualitative only.

Phosphates, ,, ,,

Chlorides.

REAGENTS REQUIRED FOR THE ANALYSIS

Physical Characters and Reaction.

Caustic Soda solution, 10%.
Decinormal Hydrochloric Acid solution.
,, Sodium Carbonate solution.
Alcoholic solution of Methyl-orange.

Wanklyn's Process.

Standard solution of Ammon. Chloride, 1 c.c.=0·01 mgm.NH.
Nessler Reagent.
Alkaline Potassium Permanganate.
Sodium Carbonate (pure).

Tidy's Process.

Standard solution of Potassium Permanganate, 1 c.c. = 0·1 mgm. Oxygen.
Sulphuric Acid, 1 in 3.
Potassium Iodide solution.
Sodium Hyposulphite solution.
Starch solution.

Winkler's Process.

Manganous Chloride solution.
Potassium Iodide and Potassium Hydrate solution.
Hydrochloric Acid (strong).
Starch solution.
Standard solution of Sodium Thiosulphate, 1 c.c. = 0·25 mgm. Oxygen.

Nitrites.

Meta-phenylene-diamine solution.
Sulphuric Acid, 1 in 3.
Standard solution of Potassium Nitrite, 1 c.c. = 0·01 mgm. N. as Nitrite.

Nitrates.

Brucine solution.
Sulphuric Acid (strong).
Standard solution of Potassium Nitrate, 1 c.c. = 0·01 mgm. N.
Ammonia solution, 25%.
Sulpho-carbolic Acid.

Hardness.

Standard solution of Soap, 1 c.c. = 1 mgm. $CaCO_3$ or its equivalent.

Poisonous Metals.

Sodium Sulphide solution.
Potassium Cyanide solution.
Potassium Ferro-cyanide solution.
Potassium Chromate solution.
Hydrochloric Acid (dilute).
Standard solutions of Iron, Lead and Copper, 1 c.c. = 1 mgm. of the metal.

Sulphates.

Barium Chloride solution.
Hydrochloric Acid dilute.

Phosphates.

Ammonium Molybdate solution.
Nitric Acid (strong).

Chlorides.

Standard solution of Silver Nitrate, 1 c.c. = 1 mgm. Cl.
Potassium Chromate solution.

Physical Characters.

Colour.—Fill a clear white glass tube 2 feet long with the water. View through the depth on to a white porcelain slab, hold tube 3 inches above the slab and face the light. Most waters are very pale green, probably due to the presence of infinitesimal growths of vegetable organisms. A brown colour usually denotes peat, or very fine particles of iron or other suspended matter, which may be removed by filtration or dissolved with weak acids.

Smell.—Most waters are inodorous, unless medicinal, or grossly polluted with sewage or decaying vegetable matter. To bring out the smell, nearly fill a bottle with the water, slightly alkalise with weak potassic hydrate solution, stopper, and warm for a few minutes. In this way the gases are disengaged, and their presence can be detected when the stopper is removed.

Taste.—As a general rule it is unwise to taste a water. The pleasant taste is due to the dissolved gases, since boiled water, or water which has been de-aerated, is flat and insipid. Iron, as little as $\frac{1}{4}$ grain per gallon, will impart a chalybeate flavour. Common salt when in excess will furnish a brackish taste.

Lustre depends upon the amount of dissolved gases. If, when the water is allowed to stand in a glass vessel for some time, bubbles of gases can be seen adhering to the inner surface of the glass, it is well aerated and therefore lustrous.

Clearness.—This is controlled by the amount of fine particulate matter in suspension. It is of little significance.

Suspended and Deposited Matter.—The nature, rather than the

amount, has the greater health importance. As filtration will remove most of it, it becomes of less consequence still. A rough examination can be carried out as follows. Allow the water to stand in a conical test-glass for some hours. Then siphon off the water from any deposit and burn the residue in a platinum dish. Does it char or scintillate? Does it give off fumes, and do the fumes smell of burning feathers or horn? These suggest organic matter.

To the residue add some HCl. Is most dissolved, and does it effervesce? If so, chalk is present. What is undissolved is probably sand or clay, or both. Iron can be detected by the blue colour which results on the addition of ferro-cyanide of potassium.

The microscope reveals sometimes, in the case of very foul waters, ova of various intestinal worms, human hair, all sorts of vegetable growths, spores, etc. In the water itself, one occasionally sees macroscopic objects swimming about, such as Cyclops, Daphnia Pulex, Grammarus Pulex, and other animal organisms. These are not necessarily significant of gross pollution.

Reaction.—Most waters are either neutral or faintly alkaline. Peaty waters are frequently acid. Rarely an amphoteric reaction is met with. In this case the water is really alkaline, the acid reaction being due to free CO_2. To test the reaction, dip half of a blue litmus paper and half of a red litmus paper in the water for five minutes, and note result. To estimate the amount of alkalinity or acidity, decinormal solutions are required.

A normal solution, written $\frac{N}{1}$, is the molecular weight of the substance in grams, having regard to its valency or basicity, dissolved in a litre of distilled water. The valency is the number of hydrogen atoms which can be combined with or displaced. The valency of a base is the number of hydroxyl groups it contains. Thus, NaOH is monovalent, $Ba(OH)_2$ is divalent. The valency of a salt is equal to the valency of its acid. Thus, NaCl is monovalent, as HCl is monovalent; Na_2CO_3 is divalent, as H_2CO_3 is divalent. The valency of an inorganic acid is equivalent to the number of hydrogen atoms it contains. Therefore H_2SO_4 is divalent, HNO_3 is monovalent. The valency of an organic acid corresponds to the number of carboxyl groups in its chemical construction.

Supposing it is required to make a normal solution of Na_2CO_3: the molecular weight is 106.

The 106 is halved, as Na_2CO_3 is divalent.

$\therefore$ 53 grams of water-free sodium carbonate per litre of distilled water equals an $\frac{N}{1}$ solution.

∴ 1 c.c. will contain one-thousandth part of 53 grams, *i. e.* 0·053 gram or 53 milligrams.

A decinormal solution, written $\frac{N}{10}$, will obviously have dissolved in each c.c. of it 0·0053 gram, or 5·3 milligrams, of Na_2CO_3.

Required to make an $\frac{N}{10}$ solution of potassium permanganate. The molecular weight of $K_2Mn_2O_8$ is 316.

Since five atoms of the oxygen are available for oxidising purposes, and as oxygen is divalent, potassium permanganate is decivalent.

∴ a normal solution contains 31·6 grams per litre of distilled water.

∴ 1 c.c. of an $\frac{N}{10}$ solution contains 0·00316 gram of potassium permanganate.

All $\frac{N}{10}$ solutions are made up on these lines.

The Estimation.—To a clean white porcelain bowl add 100 c.c. of the water. Add a few drops of an alcoholic solution of methyl-orange as an indicator. This strikes a yellow colour with alkalis, and red with acids.

N.B.—Phenolphthalein cannot be used, as it does not react satisfactorily in the presence of free carbonic acid.

Then run in $\frac{N}{10}$ solution of acid or alkali, according to whether the water is alkaline or acid, until the colour is changed.

Say 5 c.c. of $\frac{N}{10}$ H_2SO_4 were required.

Then, as all decinormal solutions are equal to each other, bulk for bulk, the alkalinity of 100 c.c. of water = 5 c.c. of $\frac{N}{10}$ solution of sodium carbonate.

As 1 c.c. of $\frac{N}{10}$ sodium carbonate = 5·3 mgms. Na_2CO_3,

then 5 c.c. ,, ,, ,, = 26·5 ,, ,,

∴ there are 26·5 mgms. of Na_2CO_3 in 100 c.c. of water.

It is usual to express everything in water analysis as parts per 100,000.

100 c.c. of water weigh 100 grams.

1 gram = 1000 mgm.

∴ 100 c.c. of water = 100,000 mgms.

∴ there are 26·5 mgms. of Na_2CO_3 in 100,000 mgms. of water, or the alkalinity = 26·5 parts of sodium carbonate per 100,000 parts of water.

Wanklyn's Process.

Free and Saline Ammonia Estimation.—Measure 500 c.c. of the water into a glass boiling-flask. Add a pinch of pure sodium carbonate to liberate any ammonia which might be fixed by an acid. Attach flask to a condenser, which has been previously cleaned by distilling some ammonia-free water through it. Turn water tap on to allow a steady stream of water to flow through the outer tube of condenser. Boil water briskly until three Nessler glasses have each been filled to the 50 c.c. mark with distillate. Add 2 c.c. of Nessler reagent to each glass. If a yellow colour appears in the third, this collection of distillate must be continued until no colour is produced on adding the Nessler reagent. Pool the whole distillate; say three glasses were collected. Pour a third of the mixture into a Nessler glass, and match the colour as follows. Nearly fill another Nessler glass to the 50 c.c. mark with ammonia-free distilled water. Add to it an amount of standard solution of ammonium chloride which it is thought will not quite match the colour in the sample cylinder when the Nessler reagent is added. This is experimental. It is essential that the ammonium chloride solution should be added before the Nessler reagent. If not, a turbidity ensues which renders accurate matching an impossibility. A little extra ammonium chloride solution may now be added until an exact match is produced.

Say 2·5 c.c. of S.S. ammonium chloride were required.

$\therefore$ this amount matched one-third of the distillate.

$\therefore$ the whole distillate $= 3 \times 2{\cdot}5 = 7{\cdot}5$ c.c. of ammonium chloride solution.

But the ammonia that is in the distillate was originally in 500 c.c. of the sample water.

$\therefore$ the ammonia in 500 c.c. of water $= 7{\cdot}5$ c.c. ammonium chloride solution. But 1 c.c. of S.S. ammonium chloride $= 0{\cdot}01$ mgm. NH_3.

$\therefore$ 7·5 c.c. of S.S. ammonium chloride $= 0{\cdot}075$ mgm. NH_3.

$\therefore$ there is 0·075 mgm. NH_3 in 500 c.c. of water, or 0·015 mgm. NH_3 in 100 c.c. of water, or 0·015 mgm. NH_3 in 100,000 mgm. of water.

$\therefore$ the free and saline ammonia $= 0{\cdot}015$ part per 100,000 parts of water.

Albuminoid Ammonia Estimation.—To the water remaining in the flask add 50 c.c. of alkaline potassium permanganate solution, which has been made ammonia-free by boiling. This is best done by adding to a beaker 50 c.c. of the alkaline potassium permanganate and 150 c.c. of distilled water, and *boiling* for half an hour. Re-attach flask to condenser, and distil slowly three more glasses, or until no more ammonia comes over as evidenced by the absence of yellow colour on adding the Nessler reagent. The matching and calculation are done as before.

Tidy's Process for Estimating the Amount of Oxidisable Organic Matter.—Take two stoppered flasks (about 200 c.c. capacity), and measure into one 100 c.c. of the sample water, and into the other 100 c.c. of distilled water. Add to both 10 c.c. of the S.S. potassium permanganate, followed by 10 c.c. of sulphuric acid (1 in 3). Keep at a temperature of 80° F. for fifteen minutes, or two hours, or four hours, according to whichever observation is required. When the time has expired, say two hours, add a sufficient amount of potassium iodide solution to render both of them distinctly yellow. Into one of them discharge, by means of a burette, a solution of sodium hyposulphite, drop by drop, till the yellow colour is almost gone. Add starch solution; a blue colour will result, due to blue iodide of starch. Resume the addition of the sodium hyposulphite until the blue colour just disappears. Repeat this procedure with the other flask.

Calculation, e. g.—

Control required 18·4 c.c. of sodium hyposulphite.
Sample ,, 16·2 ,, ,, ,,

18·4 c.c. of sodium hyposulphite = 10 c.c. of potassium permanganate solution.

N.B.—There was no organic matter in the control, that is, the distilled water, and therefore the 10 c.c. of potassium permanganate solution remained undecomposed. The sample would also have taken 18·4 c.c. if it had contained no organic matter, but, as it required 16·2 c.c., the difference (2·2 c.c.) must equal the amount of oxidisable organic matter the 100 c.c. of sample water contained.

Since 10 c.c. of potassium permanganate solution = 1 mgm. of O_2, the 18·4 c.c. of sodium hyposulphite solution must also equal 1 mgm. of O_2.

$$\therefore \text{ the difference } 2{\cdot}2 \text{ c.c.} = \frac{2{\cdot}2 \times 1}{18{\cdot}4} = 0{\cdot}12 \text{ nearly.}$$

∴ the oxidisable organic matter in 100 c.c. of sample absorbed 0·12 mgm. of oxygen, or the oxygen absorbed in two hours at 80° F. = 0·12 part per 100,000.

If the pink colour of the potassium permanganate disappears in the sample before the end of the two hours, another 10 c.c. must be added, or even more, as the pink colour must be present at the end of the two hours. Due allowance must be made for such additions in the calculation. It is not necessary to add more potassium permanganate to the control.

N.B.—Most of the yellow colour should be discharged before the starch solution is added. The starch solution should be weak, and boiled thoroughly before use. A penknife tip of starch powder to a test-tube of water is sufficient.

Winkler's Process for Estimating the Amount of Dissolved Oxygen.—Fill a glass-stoppered bottle of known capacity with

the water. This must be done carefully, in order to prevent, as much as possible, the water taking up oxygen from the air. Insert stopper to the exclusion of all air bubbles. (The base of the stopper should be rounded off.) Add 1 c.c. of manganous chloride solution, followed by 2 c.c. of a mixture of potassium iodide and potassium hydrate. Re-insert stopper. Obviously 3 c.c. of water will be displaced. Allow to stand for fifteen minutes in a dark place, after mixing thoroughly. A brown precipitate of manganous and manganic oxides will have formed and settled. To a flask add 5 c.c. of strong hydrochloric acid. Pour contents of bottle into flask. A yellow colour of free iodine results. From a burette, drop by drop, discharge into flask a standard solution of sodium hyposulphite, until the yellow colour is almost gone. Add starch solution. Resume addition of hyposulphite until blue colour just disappears.

Calculation.—Say 12 c.c. of sodium hyposulphite were required.

Let capacity of bottle be 315 c.c., less 3 c.c. for water displaced = 312 c.c.

∴ the oxygen in 312 c.c. of water = 12 c.c. of sodium hyposulphite.

But 1 c.c. of hyposulphite = 0·25 mgm. of O_2.

∴ 12 „ „ = 3·0 „ „

∴ there were 3 mgm. of O_2 in 312 c.c. of water, or $\frac{3 \times 100}{312}$ = 0·96 mgm. O_2 in 100 c.c. of water, or oxygen dissolved = 0·96 part per 100,000.

It is not usual to make this estimation in an ordinary analysis of water.

A water saturated with air at the ordinary temperature contains about 1 part of dissolved oxygen per 100,000 parts of water.

This process then estimates the amount of oxygen dissolved, in contradistinction to Tidy's process, which, as we have seen, determines the amount of organic matter in terms of oxygen absorbed from potassium permanganate. The two processes are in inverse ratio.

Nitrites.

Qualitative Test.—To one Nessler glass add 50 c.c. of the sample water; to another, 50 c.c. of distilled water.

To a test-tube half filled with distilled water add a penknife tip of meta-phenylene-diamine and 3 drops of dilute sulphuric acid. Add 1 c.c. of this solution to each of the two cylinders. Keep in a warm place for fifteen minutes. The sample will develop a yellow colour if nitrites are present. The quantitative estimation may be made by matching the colour against a standard solution of potassium nitrite.

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Nitrates.

Qualitative Test.—Half fill a test-tube with the sample water. Add about 3 c.c. of a saturated solution of brucine. Pour down the side of the tube pure and strong sulphuric acid. Hold the tube well on the slant, and keep it so until a layer of H_2SO_4 can be seen distinctly at the bottom of the tube. Shake the tube; a pink zone appears at the junction of the acid and water, in the presence of nitrates. With a large amount, the pink rapidly changes to a yellow.

Quantitative Estimation. Picric Acid Process.—Take two shallow porcelain dishes, and add to one 10 c.c. of the water and to the other 10 c.c. of a standard solution of potassium nitrate. Evaporate both to dryness on the water-bath. To each add 3 c.c. of sulpho-carbolic acid, and leave on the bath for another five minutes. Transfer contents of dishes to two separate Nessler glasses. Wash the dishes out with 25% ammonia, and pour the washings into their respective glasses. Then add ammonia till no further deepening of the yellow colour occurs. Make up to 50 c.c. with distilled water. From the deeper yellow glass remove such quantity to a third Nessler glass, that, when made up to 50 c.c. with distilled water, it matches the lighter yellow glass.

Calculation, e.g. 10 c.c. of the 50 c.c. of the control (or S.S. KNO_3) glass matched the sample cylinder.

The control 50 c.c. = 10 c.c. of S.S. KNO_3.

1 c.c. of S.S. KNO_3 = 0·01 mgm. of N. as nitrate.
∴ 10 ,, ,, = 0·1 ,, ,, ,,
∴ 50 ,, control = 0·1 ,, ,, ,,

Now 10 c.c. of this 50 c.c. = the nitrate in 10 c.c. of water sample.

$\therefore \frac{10}{50}$ of 0·1 mgm. N. = amount of nitrate in 10 c.c. of water.
= 0·02 mgm. N. in 10 c.c. of water.
= 0·2 ,, ,, 100 ,, ,,
or 0·2 part of nitrate per 100,000 parts of water.

N.B.—This calculation can be simplified (*a*) where the control cylinder is the deeper yellow, $\frac{x}{50}$ = parts of N. per 100,000 parts of water;

(*b*) where the sample cylinder is the deeper one, $\frac{50}{x}$ = parts per 100,000.

x in both cases = amount required to match.

Chlorine Estimation.—Measure 100 c.c. of the sample water into a white porcelain bowl. Add a few drops of potassium chromate solution. Discharge from a burette, drop by drop, a

standard solution of silver nitrate, until the lemon yellow of the water is changed to a distinct orange colour. Note the amount of standard solution used.

Calculation.—Say 2·0 c.c. of the S.S. silver nitrate were added.

1 c.c. of the S.S. = 1 mgm. of Cl.
∴ 2 " " = 2 " "

There are 2 mgm. of Cl. in 100 c.c. of water, or 2 parts per 100,000.

To express the result in terms of sodium chloride, the chlorine result is multiplied by $\frac{58 \cdot 46}{35 \cdot 46} = 1 \cdot 65$, *i. e.* $2 \times \frac{58 \cdot 46}{35 \cdot 46}$ = parts of NaCl.

NaCl to Cl is as 58·46 is to 35·46 (Na = 23, Cl = 35·46).

N.B.—The red chromate of silver that is formed in the process is dissolved by acids. An acid water, therefore, should be neutralised with pure sodium carbonate before the estimation is made.

Total Hardness.—Measure 100 c.c. of the sample water into an 8 oz. stoppered bottle. From a burette discharge the S.S. soap, 1 c.c. at a time, well shaking the bottle after each addition, until a lather remains permanent for five minutes.

Calculation.—Say 16 c.c. of soap solution were required. Now 1 c.c. of the soap solution = 1 mgm. of $CaCO_3$, or its equivalent.

∴ 16 c.c. of soap solution = 16 mgm. of $CaCO_3$. But as 100 c.c. of distilled water require 1 c.c. of soap solution to produce the typical lather, this amount must always be deducted from the quantity used up by the sample.

∴ there are 15 mgms. of $CaCO_3$, or its equivalent, in 100 c.c. of water.

∴ Total hardness = 15 parts per 100,000.

Permanent Hardness.—Measure 100 c.c. of the sample water into a beaker, and *boil* for fifteen minutes. Cool. Filter into a 100 c.c. graduated flask. Make up the 100 c.c. with distilled water. Repeat the soap experiment with this, and calculate as before.

Total Hardness – Permanent Hardness = Temporary Hardness.

N.B.—If more than 25 c.c. of the soap solution are required, it is advisable to dilute the water with an equal quantity of distilled water, as the copious precipitate which comes down when soap is added to a hard water inhibits the formation of the lather. With waters containing an excess of magnesium salts, a scum forms when the soap solution is added. This scum, which presents a dirty appearance, must not be mistaken for a true lather. In such a case the water should be diluted with an equal quantity of distilled water, the soap solution added, and the bottle thoroughly shaken after each addition.

To convert parts per 100,000 into degrees of hardness according to Clark's scale, the former is multiplied by 0·7. A degree of hardness is a grain per gallon.

∴ in the example given the $15 \times 0{\cdot}7 = 10{\cdot}5$ grains per gallon, or 10·5 degrees.

There are 70,000 grains in a gallon.

∴ 1 grain per gallon is 1 part per 70,000 parts. This, to parts per 100,000, is as 70,000 is to 100,000.

∴ 1 grain per gallon is 0·7 of a part per 100,000.

Total Solids. Estimation.—Weigh a clean platinum dish. Into it measure 20 c.c. of the sample water. Evaporate to dryness on the water bath. Wipe the superfluous moisture off the outside, and place the dish in hot air oven at 90° C. for thirty minutes. Desiccate for ten minutes and reweigh.

Calculation, e. g. weight of dish + solids = 15·446 grams.
,, ,, (clean) = 15·440 ,,
∴ weight of solids from 20 c.c. of water = 0·006 grams.
∴ ,, ,, ,, 100 ,, ,, = 0·030 ,,
∴ Total solids = 30 parts per 100,000.

Incinerate residue at a dull red heat until any evidence of charring disappears. Desiccate, reweigh and calculate as before. This will equal the figure of Non-volatile solids. Total solids − Non-volatile solids = Volatile solids.

Poisonous Metals.

Qualitative Tests.—Pour into a white porcelain bowl about 100 c.c. of the sample water. Add a drop or two of sodium sulphide solution, or pass some H_2S gas through it. A black or brown discoloration indicates the presence of iron, copper or lead. Divide discoloured water into two parts. To one add 2 or 3 drops of dilute hydrochloric acid; if the darkening disappears, the metal is iron. If not, to the other portion add a few drops of a solution of potassium cyanide. If the colour goes, copper is present; if it does not, then lead is strongly suspected. If no darkening presents itself on the addition of sodium sulphide, zinc should be tested for as follows—

To some of the water in a Nessler glass add a drop of sodium sulphide solution; avoid shaking. A white gelatinous precipitate forms with zinc.

To more of the water in a Nessler glass add 2 drops of dilute hydrochloric acid and 2 drops of a solution of ferro-cyanide of potassium: a blue colour confirms the presence of iron; a brown colour, copper; and a white precipitate, zinc.

To corroborate the presence of lead. Take two Nessler glasses, half fill one with the sample water, and the other with distilled water. Add to each equal quantities of potassium chromate solution, and a drop or two of acetic acid, and allow to stand

for fifteen minutes. A turbidity in the sample cylinder denotes the presence of lead.

N.B.—The potassium ferro-cyanide test is a very delicate one; it is recommended, therefore, that this test should be employed as a routine practice.[1]

Sulphates.—To a test-tube half filled with the water add 2 drops of hydrochloric acid, followed by a few drops of barium chloride solution. A turbidity or a copious white precipitate ensues, according to the amount of sulphate present.

Phosphates.—To a test-tube half filled with the water add about 2 c.c. of ammonium molybdate solution, followed by strong nitric acid to render distinctly acid. Then add, drop by drop, more ammonium molybdate solution (do not shake the tube) until about 12 to 20 drops have been added in all. Allow to stand for fifteen minutes. In the presence of phosphates, a yellow tinge and turbidity appear near the surface of the mixture.

N.B.—As a rule phosphates are not found in ordinary waters without concentration. To detect small quantities, evaporate 500 c.c. of the water, after acidulating with a drop or two of nitric acid, to a few cubic centimetres, and then test as above described.

An analysis should be completed in three hours.

The following scheme is recommended—

1. Start Wanklyn's Process.
2. Start Tidy's Process.
3. Start the evaporation for the estimation of the Total Solids.
4. Start the water boiling for the Permanent Hardness Estimation.
5. Start the Picric Acid Process for the Nitrate estimation.
6. By this time the Free Ammonia will probably be over. If so, add the alkaline permanganate solution to the flask, and start distilling over the Albuminoid Ammonia.
7. Estimate the amount of Free Ammonia.
8. Estimate the Chlorides.
9. Estimate the amount of Total Hardness.
10. Finish the Permanent Hardness estimation.
11. Test for Sulphates, Phosphates and Nitrites.
12. If over, estimate the Albuminoid Ammonia.
13. Finish the Picric Acid Process.
14. Finish the estimation of the Total Solids.
15. Test for, and if necessary estimate, the amount of Poisonous Metal.
16. Finish Tidy's Process.

[1] The quantitative determination may be made by matching the discoloration produced with sodium sulphide, against a series of bowls, each containing distilled water, sodium sulphide and a known but different amount of a standard solution of the metal that was found.

A water is reported upon under the following heads—

A. Its probable source.
B. Its fitness for drinking purposes.
C. Its fitness for other purposes.

A. It is often impossible to be specific as to the exact source or origin of a water. Thus a river water, on account of the entrance into it of water from tributaries, springs, etc., and of the varying nature of the country through which it flows, is constantly changing in type. On the other hand, a water which has percolated certain strata, such as chalk, limestone, greensand, will have a fairly large amount of inorganic solids in solution, with a correspondingly high figure of hardness. Waters from upland surfaces, peaty water, rain water, will have low figures of inorganic solids and hardness. Therefore one can only say that the water is a surface one, or from a depth, by the amount of inorganic solids it contains. This practically represents the limits to which one can go. A knowledge of the geological conditions of the district in which the water is collected, will help one in drawing more definite conclusions, but where this information is not available, the probable source must be stated with reservation. On reporting on a water, however, one should always keep in mind its probable source. A water with anomalies which could not be accounted for by strata should be regarded with suspicion. Thus a water from a nitrate-bearing stratum would not be viewed with such a critical eye as another water also containing a large amount of nitrate which could not be accounted for by strata.

B. Its fitness for drinking purposes depends upon: (1) the amount of inorganic salts in solution, (2) the presence and amount of a poisonous metal, and (3) the nature and degree of organic pollution.

As regards (1), calcium, magnesium and sodium sulphates have a direct bearing upon the health of the consumer. New-comers to a district supplied with water containing these salts are liable to suffer from diarrhœa and general intestinal disturbances. Continued use, on the other hand, will almost invariably produce a condition of constipation. The amount present is indicated by the Non-volatile Solids figure, and the Hardness. The former should not be in excess of 100 parts per 100,000, and the latter 30 parts per 100,000, of which not more than 10 parts should be Permanent. If, however, the Hardness is the only objectionable feature of a water, a softening process would probably remedy the defect.

As regards (2), the poisonous metals that are usually considered are Iron, Copper, Lead and Zinc. (The rarer ones, such as Arsenic, Chromium and Tin, are not tested for unless a special case is indicated.) Their presence is invariably accounted for by the passage of the water through metal pipes or cisterns.

The following amounts should not be exceeded—

Iron	$\frac{1}{4}$ grain to the gallon.
Lead	$\frac{1}{20}$,, ,, ,,
Copper . . .	$\frac{1}{15}$,, ,, ,,
Zinc	$\frac{1}{10}$,, ,, ,,

(There is no evidence that more than this amount of zinc is harmful.)

As regards (3), organic matter is of either vegetable or animal origin, *i. e.* harmless or harmful. It is impossible to give an opinion on any one figure of the analysis, the *whole* of the results must be considered together. Thus, animal contamination raises the figures of Free and Saline Ammonia, Albuminoid Ammonia, Chlorine, Nitrites, Nitrates, and Oxygen absorbed from permanganate, frequently along with the amount of Volatile Solids. Vegetable contamination is evidenced by an increase in the figures of Albuminoid Ammonia, Oxygen absorbed from potassium permanganate, and Volatile Solids, all other figures being low.

A rough guide with regard to the Ammonias is, that if the Albuminoid figure reaches 0·008 part per 100,000, the Free and Saline must not exceed 0·005 part per 100,000. (In a pure upland-surface water, however, the Free and Saline Ammonia should never exceed 0·001 parts.) The Nitrates, inasmuch as they are the ultimate product of oxidisation of Ammonia, should not exceed 0·1 part unless furnished by strata. On the other hand, if there is no other evidence of organic pollution *per se*, this figure may be raised to 0·5 part, but it must be clearly understood that such a figure is suggestive of past contamination. It is not sufficient to warrant actual condemnation, but an opinion should be stated with reserve. Nitrites, which represent only partially oxidised ammonia, therefore recent animal pollution, should always condemn a water unless due to reduction of Nitrates, *e. g.* by a salt of iron in greensand, iron pipes and cisterns, etc. The Chlorine figure in rain water does not exceed 0·5 part, but much higher amounts may be found in pure water from chalk or greensand strata, or from reservoirs and wells near the coast. A figure of more than 0·1 part of Oxygen absorbed from potassium permanganate is suspicious, unless the Albuminoid Ammonia figure is the only other figure showing an increase, when the pollution will certainly be vegetable in type.

The following examples will serve to show the difference between two waters, both organically impure, one with animal matter and the other with vegetable matter—

	A.	B.
Physical Characters	good	slight brown colour
Reaction	neutral	faintly acid
Free and Saline Ammonia	0·011	0·0005
Albuminoid Ammonia	0·009	0·018

	A.	B.
Total Solids	31	10
Volatile Solids	18	9
Non-volatile Solids	13	1
Total Hardness	9	4
Permanent Hardness	6	4
Temporary "	3	0
Chlorides	2·5	0·4
Nitrates	1·4	0·07
Nitrites	trace	nil
O_2 absorbed in 2 hours at 80° F.	0·13	0·21
Poisonous Metals	nil	nil
Sulphates	trace	nil
Phosphates	trace	nil

All in parts per 100,000.

A. is a shallow well water contaminated with sewage.

B. is a typical peaty water.

C. Its fitness for purposes other than drinking, chiefly washing and cooking.

The Hardness figure is probably the most important. A water with less than 10 parts per 100,000 is considered soft, between 10 and 20 hard, between 20 and 30 very hard, and over 30 almost unusable. The fact that a water is amenable to a softening process must never be lost sight of.

Let it be supposed that a water gave the following results, and we are asked to report upon it—

Physical Characters	excellent
Free and Saline Ammonia	0·0021 parts per 100,000
Albuminoid Ammonia	0·003 " " "
Total Solids	41 " " "
Volatile Solids	9 " " "
Non-volatile Solids	32 " " "
Total Hardness	28 " " "
Permanent Hardness	3 " " "
Temporary "	25 " " "
Chlorides	3·1 " " "
Nitrates	0·29 " " "
Nitrites	nil " " "
Poisonous Metals	nil " " "
Sulphates	trace " " "
Phosphates	trace " " "
O_2 absorbed in 2 hours at 80° F.	0·035 " " "

Firstly, as to its *probable source.* On looking at the Non-volatile Solids and Hardness, we judge the water to have come from a depth, as both figures are moderately high, and yet not high enough to warrant condemnation. Of the 28 parts of Total Hardness no less than 25 are Temporary. In view of this we are justified in saying that the water is probably from the chalk.

Secondly, its *fitness for drinking purposes.* There is no excess of mineral matter, nor does it contain a poisonous metal. On these grounds, therefore, it is quite safe.

As to organic contamination, the Free and Saline Ammonia and the Albuminoid Ammonia are both low. This proves that vegetable organic matter, if present at all, is in a negligible amount, and that any animal pollution is not of a recent origin. This is confirmed by the low figure of Oxygen absorbed, and also by the fact that the Volatile Solids form only a small proportion of the whole. Phosphates are usually regarded as being significant of animal pollution. In this particular water a trace is present, but this might have been derived from the chalk, and is consequently of little importance. The Nitrates and Chlorides are, *per se*, fairly high, but they cannot possibly be due to organic matter existing at the moment, with an Albuminoid Ammonia figure of only 0·003. Presumably, therefore, they can be accounted for in some other way. Chalk itself we know, will sometimes raise the figures of Nitrates and Chlorides to 0·4 or 0·5 and 3 or 4 respectively.

From these arguments we have no reason to believe that this water is sewage polluted, as any slightly increased amount of any item in the analysis is consistent with strata through which the water has percolated. We hold the view, therefore, that this water is quite fit for drinking purposes.

Thirdly, its fitness for other purposes. The Total Hardness is certainly a little high, but it must be remembered that most of it is removable. For washing and cooking purposes, therefore, it could be used if it were softened beforehand.

Report upon the following sample—

Physical Characters	slight brown colour, faintly acid in reaction	
Free and Saline Ammonia	0·0038	parts per 100,000
Albuminoid Ammonia	0·015	,, ,, ,,
Total Solids	14	,, ,, ,,
Volatile Solids	11	,, ,, ,,
Non-volatile Solids	3	,, ,, ,,
Total Hardness	4	,, ,, ,,
Permanent Hardness	4	,, ,, ,,
Temporary ,,	0	,, ,, ,,
Chlorides	2·1	,, ,, ,,
Nitrates	0·3	,, ,, ,,
O_2 absorbed in 2 hrs. at 80° F.	0·21	,, ,, ,,
Poisonous Metals	nil	,, ,, ,,
SO_4	nil	,, ,, ,,
P_2O_5	nil	,, ,, ,,

Probable Source.—It is soft, and the amount of inorganic solids is low, therefore it is a surface water; and as it is brownish in colour and slightly acid in reaction, it presumably is a peaty water. This is confirmed by the high figures of Albuminoid Ammonia and Oxygen absorbed.

Fitness for Drinking Purposes.—There is no excess of mineral matter, and poisonous metals are absent; therefore it is quite fit as far as these are concerned. The water is condemned,

however, on account of sewage contamination, as evidenced by the fairly high figures of Free Ammonia, Chlorides and Nitrates. These are not high *per se*, but in view of the fact that the water has a surface origin, and that, therefore, they cannot be accounted for by strata, they must be regarded with suspicion.

These are the lines on which a report is made. Occasionally the results are bewildering, or even problematical, especially with a "border-line" water. It need not be urged that, in such a case, the opinion should be guarded and non-committal. It would be wise to suggest a bacteriological analysis of the water and a careful local survey of the source.

The following bacteriological standards are recommended by Houston—

	Deep well water.	Shallow well water.
Gelatine (72 hours at 22° C.)	not more than 50 per c.c.	not more than 500 per c.c.
Agar (48 hours at 37° C.)	not more than 5–10 per c.c.	not more than 50 per c.c.
B. Coli	absent in 100 c.c.	absent in 10 c.c.
Streptococci	„ „ 100 c.c.	„ „ 10 c.c.
B. Enter. Sporogenes	„ „ 1000 c.c.	„ „ 100 c.c.

The bacteria of the water can be grouped as follows—

1. Normal Flora . . . . . *e. g.* Fluorescens Liquifaciens.
2. Soil organisms . . . . . *e. g.* Subtilis.
   Mycoides.
   Cladothrix.
3. Excremental organisms . . . *e. g.* B. Coli.
   Streptococci.
   B. Enter. Sporogenes.

The bacterial count is of value, but it is obvious that the presence of micro-organisms associated with sewage is of greater importance.

Taking the Coli Communis content of sewage as 100,000 per c.c., then the following table must follow—

No Coli in 100 c.c. water		= pollution of less than	0·00001% of sewage.
Coli in 100	but not in 10 c.c.	= pollution with	0·00001% „ „
„ „ 10	„ „ „ 1 „	= „ „	0·0001% „ „
„ „ 1	„ „ „ 0·1 „	= „ „	0·001% „ „
„ „ 0·1	„ „ „ 0·01 „	= „ „	0·01% „ „
„ „ 0·01	„ „ „ 0·001 „	= „ „	0·1% „ „
„ „ 0·001	„ „ „ 0·0001 „	= „ „	1% „ „
„ „ 0·0001	„ „ „ 0·00001 „	= „ „	10% „ „
„ „ 0·00001		= „ „	100% „ „

SEWAGE EFFLUENTS

A sewage effluent is nothing more than a grossly polluted water; it is analysed, therefore, in much the same way, with a few modifications as to dilutions.

It is not usual to estimate the Hardness, Poisonous Metals, Sulphates and Phosphates.

Physical Characters.

1. Colour.
2. Turbidity (degree of) or clearness.
3. Deposited and suspended matter.
4. Smell, direct, and after forty-eight hours' incubation at 37° C.

Before proceeding with the analysis it is necessary to make a preliminary test to ascertain to what extent the effluent should be diluted for Wanklyn's and Tidy's processes. To a Nessler glass containing 50 c.c. of ammonia-free distilled water add 5 c.c. of the effluent and 2 c.c. of Nessler reagent, and note the amount of yellow colour which develops. If it is as deep as mahogany, not more than 10 c.c. should be taken for Wanklyn's Process, and not more than 20 c.c. for Tidy's Process. Larger amounts may be taken if the colour is less.

Wanklyn's Process.—To 500 c.c. of ammonia-free distilled water in a boiling flask add 10 c.c. of the effluent, assuming this to be the amount decided upon by the preliminary test. Render alkaline with sodium carbonate, and then proceed as in water analysis.

Tidy's Process.—Add to each of two flasks 100 c.c. of distilled water, 10 c.c. of potassium permanganate solution, and 10 c.c. of dilute sulphuric acid. To one add 20 c.c. of the effluent, and then proceed in the ordinary way. In making the calculations, do not forget the dilutions.

N.B.—Keep a watchful eye on the sample flask, for if much oxidisable matter is present, the pink colour will disappear. This necessitates the addition of more potassium permanganate solution.

The Chlorine, Total Solids, and Nitrates are estimated as in water analysis. As a rule no dilution of the effluent is necessary.

The estimation of the Solids in Suspension is a long and tedious process, if the amount is to be determined with absolute precision. A figure exact enough for most practical purposes may be obtained by estimating the amount of Total Solids in the well-shaken effluent, before and after filtration through several thicknesses of filter-paper, and then subtracting the results.

According to the Sewage Commissioners, that process which estimates the amount and rate of oxygen absorption is the best. The following process is, therefore, of paramount importance.

The Rideal-Stewart method for estimating the amount of Oxygen absorbed in five days at 65° F.—

Measure 200 c.c. of the effluent into 800 c.c. of distilled water, and shake thoroughly. Fill two bottles of known capacity with

the mixture. Allow to stand five minutes with stoppers out. Then insert the stoppers to the exclusion of air bubbles.

Place one aside for five days at 65° F. To the other add 1 c.c. of strong sulphuric acid, and 10 to 20 drops of a strong solution of potassium permanganate. (N.B.—This is to oxidise any reducing agent, such as a nitrite or iron salt, which may be present.) Allow to stand for twenty minutes. The pink colour must remain permanent the whole time, so, if necessary, add more potassium permanganate.

At the conclusion of the twenty minutes remove the excess of colour, by adding 2 c.c. of a solution of potassium oxalate. This may take a few minutes. Then add 2 c.c. of manganous chloride solution, followed by 5 c.c. of a mixture of potassium iodide and potassium hydrate solution. If no precipitate ensues, more of the latter mixture must be added. Allow to stand for ten minutes, occasionally inverting the bottle. Into a flask containing 5–10 c.c. of strong hydrochloric acid pour the contents of the bottle. The yellow colour of the iodine is now nearly removed by adding from a burette a standard solution of sodium thiosulphate (1 c.c. = 0·25 mgm. of O_2). A little recently prepared starch solution is now added, and the titration continued until the blue colour is just discharged. Note the amount of thiosulphate used.

Calculation, e. g. 12 c.c. of thiosulphate solution were required. Capacity of bottle is 350 c.c.

As 1 c.c. of thiosulphate solution = 0·25 mgm. of O_2
12 „ „ „ = 3·0 „ „

∴ there were 3 mgms. of O_2 in 350 c.c. of mixture;

or $$\frac{3 \times 100}{350} = 0{\cdot}85 \text{ mgm. in } 100 \text{ c.c.}$$

∴ dissolved oxygen content = 0·85 part per 100,000.

In five days' time the process is repeated in every detail with the other bottle. Let the oxygen content of this be 0·55 part per 100,000, then 0·85 − 0·55 (= 0·3 mgm.) is the amount of oxygen absorbed in five days at 65° F. by an effluent diluted five times. If the effluent had not been diluted, it would have absorbed five times as much oxygen. Therefore the oxygen-absorbing capacity of that effluent is 5 × 0·3 = 1·5 parts per 100,000 at that temperature and in that time. No allowance need be made for the amount of diluted effluent displaced by the various reagents added, as all of them are considered to have approximately the same dissolved oxygen content.

The Eighth Report of the Royal Commission of Sewage Disposal states: "An effluent, in order to comply with the general standard, must not contain, as discharged, more than 3 parts per 100,000 of suspended matter, and, with its suspended matters included, must not take up at 65° F. more than 2·0

parts per 100,000 of dissolved oxygen in five days. If the dilution (with the river water) is very great the standard may be relaxed or suspended altogether. If the dilution, while not falling below 150 volumes, does not exceed 300, the dissolved oxygen test may be omitted, and the standard for suspended solids fixed at 6 parts per 100,000. If the dilution, while not falling below 300 volumes, does not exceed 500, the standard for suspended solids may be further relaxed to 15 parts per 100,000. With a dilution of over 500 volumes, all tests might be dispensed with."

With regard to the other figures of the analysis, the following may be accepted as limits, but it must be clearly understood that they are subject to great variation, according primarily to the size of the river which receives the effluent.

Free and Saline Ammonia	1·5 parts per 100,000
Albuminoid Ammonia	0·15 ,, ,, ,,
O_2 absorbed in 2 hours at 80° F. . . .	1·5 ,, ,, ,,
Chlorine	10 ,, ,, ,,
Nitrates	2·0 (or more) ,,

AIR

The composition of moisture-free air is approximately—

Nitrogen	78·07%
Oxygen	20·95%
Argon	0·94%
Carbonic Acid	0·04%

With traces of rarer gases, ammonia, etc.

Aqueous vapour and suspended matter are invariably present; the amounts vary with certain physical conditions, as temperature, wind, etc.

Pettenkofer's Process for Estimating the Amount of Carbonic Acid.—A sample of the air to be analysed is collected in a clean glass jar of known capacity. This is conveniently done by filling the jar with water, emptying it in the place under examination, and closing it with a well-greased stopper. Avoid breathing in the direction of the jar. Note carefully the barometric pressure, temperature, and, if in a room or workshop, the number of occupants and other sources of vitiation, as gas-burners, etc.

To estimate the amount of the CO_2 in the air of the jar, take 100 c.c. of baryta water and divide into two portions of 50 c.c. Quickly add one portion to the jar (thus displacing 50 c.c. of air), restopper, and place the jar on its side for one hour. Roll it gently occasionally to ensure absorption of the CO_2. In the meantime estimate the alkalinity of the remaining 50 c.c. of baryta water by titration with standard solution of oxalic acid (1 c.c. = 0·5 c.c. of CO_2 at standard temperature and pressure), using phenolphthalein as the indicator. Note the amount of oxalic acid required to discharge the crimson colour. At the end of the

hour the alkalinity of the baryta water in the jar is estimated in precisely the same way.

For most practical purposes this titration may be carried out in the jar, without the necessity of removing any of the baryta water. It is recognised that the precipitate of barium carbonate interferes with the accuracy of the estimation; the amount, however, which forms under average conditions is so small that the resultant error is of negligible quantity.

Calculation.—The 50 c.c. of baryta water required 24 c.c. of the standard solution of oxalic acid. The 50 c.c. of baryta water in the jar required 20 c.c. Capacity of jar is 3050 c.c. Barometric pressure is 740 millimetres. Temperature is 15° C.

$\therefore$ 24 − 20 = CO_2 in air of jar, that is, in 3000 c.c., as 50 c.c. were displaced when the baryta water was added.

$\therefore$ 4 c.c. of oxalic = CO_2 in 3000 c.c. of air.

But 1 c.c. of oxalic acid = 0·5 c.c. of CO_2

$\therefore$ 4 „ „ „ = 2·0 „ „

$\therefore$ there are 2 c.c. of CO_2 at standard temperature and pressure (as the oxalic acid is made to equal a known amount of CO_2 at standard temperature and pressure) in 3000 c.c. of air at current temperature and pressure.

In order to calculate to a percentage, the volume of air must be corrected for temperature and pressure.

In accordance with Charles' and Boyle's laws, the formula is—

$$\frac{\text{Volume of air} \times 273 \times \text{current pressure}}{(273 + \text{temperature}) \times 760}$$

(*vide* chapter on Physics)

= Corrected Volume.

$$\therefore \frac{3000 \times 273 \times 740}{288 \times 760} = 2768 \text{ c.c. at standard temperature and pressure.}$$

$\therefore$ there are 2 c.c. of CO_2 in 2768 c.c. of air.

How much in 100 c.c. of air? $= \frac{2 \times 100}{2768} = 0{\cdot}072\%$.

The difference between this and the amount found in the outside air must equal added CO_2 impurity.

For other methods of carbonic acid estimation more inclusive text-books should be consulted.

Oxygen Estimation.—This test is a eudiometric one, using sodium pyrogallate as the absorbing reagent, but, as it is so infrequently carried out, its details are considered beyond the scope of this book.

Carbon Monoxide.—To test for this a large volume (100 litres) of air should be aspirated through distilled water tinged distinctly red with blood. If carbon monoxide is present, the red colour of the blood assumes a carmine tint. A more

delicate test is by means of the spectroscope. The solar spectrum consists of seven colours, in the order of red, orange, yellow, green, blue, indigo, violet. If a normal blood solution be so placed that the rays of light have to pass through it before being admitted to the spectroscope, two dark bands of oxyhæmoglobin will be apparent in the spectrum, one situated in the yellow, and the other in the green. A solution of blood containing carboxyhæmoglobin shows a very similar spectrum, but with the borders of the two bands not quite so well defined. Now add a drop or two of ammonium sulphide, warm gently, and allow to stand for fifteen minutes. The dark bands merge and become one broad one in the case of reduced hæmoglobin, whereas they persist in the case of carboxyhæmoglobin.

A quantitative estimation is very rarely done.

Ozone.—The test for ozone is best performed by exposing specially prepared paper in a cage, the sides of which are made of fine mesh copper gauze. The paper which is least reacted upon by other gases in the atmosphere is made by saturating a piece of bibulous paper with a mixture of 15 % potassium iodide solution and a 1 % phenolphthalein solution in alcohol. Ozone turns this paper a red colour, which fades and disappears on standing.

Sulphurous acid may be detected by aspirating the air through distilled water to which has been added a few drops of bromine solution. The sulphuric acid resulting is precipitated with barium chloride.

Sulphuretted hydrogen and **ammonium sulphide** are detected by exposing moistened lead acetate paper to the air. A darkening of the paper is indicative of the presence of either gas. Nitro-prusside of potassium paper is turned violet with ammonium sulphide, but is unaffected with sulphuretted hydrogen.

Phosphoretted hydrogen may gain access to the air by the disintegration of ferro-silicon, a substance employed in the manufacture of steel. To test for its presence, the air is aspirated over two papers, one moistened with nitrate of silver solution, and the other with a solution of lead acetate. The phosphoretted hydrogen will darken the silver nitrate paper, but not the other.

The **suspended matter** of the air is of a very varied nature. A microscopical examination of a sample of the dust of the air is, as a rule, the only one required. If a more exacting analysis is called for, the air may be aspirated through a sterile glass cylinder, the inside of which has been coated with gelatine or agar. The cylinder is incubated and the colonies examined. Or the air may be aspirated in such a way that it impinges upon a glass slide smeared with pure glycerine. A microscopical examination is made of the slide.

The **organic matter** of the air is estimated by aspirating a known volume through ammonia-free distilled water. Wanklyn's

and Tidy's Processes are now performed on the water (*vide* Water Analysis). The Albuminoid Ammonia seldom exceeds 0·1 mgm. per cubic metre (1000 litres) in outside air. The oxidisable organic matter should not absorb more than 5 mgms. of oxygen per cubic metre.

MILK

Composition.		Legal Limits.
Water	87·4%	
Fat	3·65%	3·0%
Protein	3·48%	8·5%
Lactose	4·75%	
Mineral Salts	0·72%	

Total Solids Estimation.—Into a weighed platinum dish measure 10 c.c. of the milk. Add 3 drops of acetic acid to precipitate the albumen. This will accelerate evaporation by tending to prevent the scum forming on the surface of the milk. Evaporate to dryness on hot water bath (this takes two to three hours). Wipe the superfluous moisture from off the outside of the dish. Place in hot-air oven at 90° C. for sixty minutes. Desiccate for ten minutes and reweigh.

Calculation—

e.g. weight of dish + solids from 10 c.c. milk = 10·978 grams
,, ,, ,, ... = 9·761 ,,
,, ,, solids . . . . = 1·217 ,,

∴ there are 1·217 grams of solids in 10 c.c. of milk.

The weight of 10 c.c. of milk can be determined from the specific gravity of the milk.

If the specific gravity is 1032, then 1000 c.c. of milk weigh 1032 grams.

∴ 10 c.c. weigh 10·32 grams.

∴ there are 1·217 grams of solids in 10·32 grams of milk.

or $\frac{1{\cdot}217 \times 100}{10{\cdot}32} = 11{\cdot}7$ grams in 100 grams of milk, or 11·7%.

The solid residue is now incinerated at a dull red heat to a grey ash. The dish is then desiccated, reweighed, and the ash or mineral solids calculated to a percentage.

Fat Estimation by Schmidt's Process.—To Stoke's tube add 10 c.c. of the milk, followed by 10 c.c. of strong hydrochloric acid. (A pink colour indicates the presence of a colouring matter, probably orange aniline.) Boil gently until mixture turns a brown colour. (If the flocculi turn a brownish yellow colour, the presence of formalin should be suspected.) Cool tube under running water. Add ether up to the 50 c.c. mark. Invert ten times. Allow to stand until the fluffy layer of casein, between the brown solution below and the ether on top, is in a compact mass. (This may be hastened by tapping the tube on a folded cloth on the table.) Remove by pipette a measured quantity (say 20 c.c.) of the supernatant ether into a weighed dish. Evaporate ether to dryness by floating the dish on water at a

temperature not exceeding 50° C. Care should be taken that no water gets into the dish, and that no naked flame is within a yard of the evaporating ether. Wipe the outside of the dish, place in hot-air oven for thirty minutes, desiccate, and reweigh.

Calculation—

e. g. weight of dish + fat from 20 c.c. of ether = 15·694 grams
" " " . . . . . = 15·371 "

∴ fat weighs . . . . . = 0·323 "

Now read off on the graduated stem of the tube the amount of ether remaining: 30 c.c. were added, but the whole amount will not separate out. Let 5 c.c. remain.

$$\therefore \frac{25 \times 0{\cdot}323}{20} = 0{\cdot}4 \text{ gram.}$$

∴ there is 0·4 gram of fat in 10 c.c., or 10·32 grams, of milk.

$$\therefore \frac{0{\cdot}4 \times 100}{10{\cdot}32} = 3{\cdot}8 \text{ grams of fat in 100 grams of milk, or } 3{\cdot}8\%.$$

The legal limit of fat is 3·0%.

To calculate the percentage amount abstracted, let 2·5% of fat be the quantity experimentally obtained. As 3% is the legal requirement, it must be assumed that no fat has been removed unless the figure falls below that amount.

∴ 3% fat = genuine milk or 100% milk: what does 2·5% equal?

That is, $\frac{2{\cdot}5 \times 100}{3} = 83{\cdot}3\%$ of genuine milk.

or 100 − 83·3 = 16·7% of fat has been abstracted.

This can be expressed as a formula.

$$\text{Percentage of fat removed} = \frac{100 \times (3 - x)}{3}$$

where x = % of fat found in sample.

The amount of water added is calculated upon the figure of Solids non-fat, the legal limit of which is 8·5% in whole milk, or 8·7% in skimmed milk.

Total Solids − Fat = Solids non-fat.

Again it must be assumed that no water has been added unless the Solids non-fat figure falls below 8·5%.

Let it be supposed that a milk yielded only 7% of non-fatty Solids.

Then as 8·5% = 100% milk

$$7{\cdot}0\% = \frac{7 \times 100}{8{\cdot}5} = 82{\cdot}3\% \text{ of milk.}$$

100 − 82·3 = 17·7% of water has been added.

$$\text{Or percentage of water added} = \frac{100 \times (8{\cdot}5 - y)}{8{\cdot}5}$$

where y = % of Solids non-fat found in sample.

Lactose Estimation.—Add 5 c.c. of milk to a 100 c.c. flask. Add 2 drops of acetic acid to curdle. Make up to the 100 c.c. with water. Filter, and make filtrate alkaline with ammonia. Run this, drop by drop, from a burette into 10 c.c. of boiling Fehling's solution (to which 50 c.c. of water have been previously added). The Fehling's solution must be kept boiling the whole time the experiment is being conducted until all the copper has been reduced, that is, until no blue colour is apparent when the flask is viewed by transmitted light.

N.B.—The Fehling's solution should be boiled in a narrow-mouth flask. By excluding as much air as possible, a more accurate estimation will be made.

Calculation.—Say 30 c.c. of the filtrate were required.

10 c.c. of Fehling's solution = 0·0678 gram lactose.

$$\therefore \quad \frac{100 \times 0{\cdot}0678}{30} = 0{\cdot}226.$$

∴ there is 0·226 gram of lactose in 5 c.c. milk.
Or $0{\cdot}226 \times 20 = 4{\cdot}52$ grams in 100 c.c. milk.
Or 4·52 grams of lactose in 103·2 grams of milk.

$$\text{Or} \quad \frac{4{\cdot}52 \times 100}{103{\cdot}2} = 4{\cdot}2\% \text{ of lactose.}$$

Cream Estimation.—Fill a cream tube up to the zero mark with the milk, and allow to stand for six to ten hours. The cream layer can be read off on the graduations on the top of the tube. Each graduation is 1%. The average amount is 8%. Boiled and "homogenised" milk yield a very small percentage.

Specific Gravity.—This can be determined either by the lactometer or the Westphal balance. The average falls between 1028 and 1034. A low specific gravity means either an excess of fat or added water. A high specific gravity may indicate that cream or fat has been removed.

Acidity.—Milk freshly drawn from the cow is either neutral or faintly alkaline, but by the time it reaches the consumer it is as a rule acid in reaction. A marked acid reaction indicates that lactic acid fermentation has set in. It may be estimated by adding $\frac{N}{10}$ sodium hydrate to 100 c.c. of milk, using phenolphthalein as an indicator, until the pink colour is permanent. It should not require more than 25 c.c. of the $\frac{N}{10}$ solution.

Dirt.—This may be estimated by allowing 1000 c.c. of the milk to stand for some hours in a conical flask, or by centrifugalising it, decanting off the supernatant liquid and washing the residue several times in water, collecting the dirt on a filter and weighing it.

Milk containing more than 10 mgms. of dirt per litre is regarded as dirty. Houston suggests that milk allowed to stand for twenty-four hours in a glass cylindrical separating flask should not yield a deposit in excess of 1 part per 10,000 by volume, and when the deposit is centrifugalised it should not exceed 1 part per 20,000.

Preservatives.—*Boric acid and borates.* To 20 c.c. of milk in a platinum dish add a drop or two of soda solution to alkalise. Boil to dryness, and incinerate. To ash add 10 c.c. of water and hydrochloric acid to render faintly acid. Boil for a few moments. Immerse half a turmeric paper in the solution. Dry paper. If the part of the paper which was wetted turns a diffused pink colour (which is converted to a greenish blue if touched with ammonia), boric acid is present.

N.B.—The turmeric paper is made more delicate if it is first moistened with oxalic acid solution, and then dried.

Salicylic Acid.—Add ferric chloride solution to the milk; a purple colour denotes the presence of salicylic acid.

A more delicate test is as follows. To 20 c.c. of the milk add a few drops of acetic acid. Filter. Add twice as much ether to filtrate. Shake well. Allow ether to separate out. Decant into a bowl. Evaporate to dryness. Add ferric chloride solution to the residue. A purple colour results in the presence of even minute amounts of salicylic acid.

Formalin.—Half fill a test-tube with milk diluted four times with water. Pour strong commercial sulphuric acid down the side of the tube, held slantwise, to form a layer at the bottom. If on slight agitation a purple zone appears at the junction of milk and acid, formalin is present. A green colour is apparent in its absence.

As this test will not respond if the formalin is in excess of 0·5%, it is advisable to dilute the milk many times before declaring it absent.

Peroxide of Hydrogen.—To the milk add a solution of "ortol." A pink colour is indicative of hydrogen peroxide.

As this test depends upon the presence of certain biological factors or enzymes, it is as well to add a few drops of pure milk to the sample before testing. Boiled milk, therefore, or milk which has had its temperature raised to a point at which the enzymes are destroyed, will not respond if hydrogen peroxide and "ortol" are added, consequently this absence of colour constitutes a test for "boiledness."

"*Mystin.*"—This is a preparation containing formalin and sodium nitrite. Its presence can be detected by testing the milk for nitrites with metaphenylene-diamine. As the nitrite masks the tests for formalin, it should be removed by adding to the milk 2 drops of sulphuric acid, a few grains of urea, and boiling the mixture for several minutes. The formalin tests may now be employed on the boiled mixture.

The **freezing-point** of milk is about $-0{\cdot}55°$ C. It appears that the point of solidification of any liquid is governed by the amount of salts in solution, and not by those substances which form an emulsion, or even those in colloidal solution. The amount of fat and proteins, therefore, does not affect the temperature of congelation. Advantage is taken of this, for any water added to milk will obviously raise its freezing-point. Many authorities are of the opinion that, if the freezing-point is above $-0{\cdot}55°$ C., water has been added.

CONDENSED MILK

In most brands of condensed milk the cows' milk, skimmed or otherwise, is reduced to about one-third of its bulk, with or without the addition of cane sugar. The degree of concentration can be determined approximately by dividing the percentage ash figure by 0·7, the average ash percentage of normal milk. To reconstitute the milk, it should be mixed with twice its weight of water, and just brought to the boil. In the case of unsweetened milk, it may now be submitted to the ordinary chemical processes of analysis, which have been described in a previous section.

With sweetened milk it is advisable to make a " stock solution " for analysis, by dissolving 20 grams of the sample in warm water, and making the total volume up to 100 c.c.

The fat may be estimated by Adam's Process. A known amount of the stock solution is taken up on specially prepared fat-free blotting-paper. The paper is then dried, placed in Soxhlet's apparatus, and the process continued on the lines indicated on p. 378.

The ash and protein can be estimated by processes described in other sections.

Lactose.—To 5 c.c. of the stock solution add a few drops of mercuric nitrate solution, and make up to 100 c.c with distilled water. Filter, alkalise filtrate with ammonia, and estimate the amount of lactose by Fehling's method.

Cane Sugar.—To another 5 c.c. of the stock solution add a few drops of mercuric nitrate solution, and make up to 50 c.c. Filter, and wash filter-paper with another 10 c.c. of water. To total filtrate add a drop or two of dilute nitric acid. Boil for one minute. Alkalise with ammonia, and make volume up to 100 c.c. Estimate the inverted sugar in this with Fehling's solution.

Calculation.—Say 10 c.c. of the 100 c.c. were required to reduce the 10 c.c. of Fehling's solution.

10 c.c. of Fehling's solution= 0·047 gram of cane sugar (after inversion).

On the assumption that the whole of the sugar is cane sugar, then 10 c.c. = 0·047 gram.

$\therefore$ the whole 100 c.c. contain $\frac{100 \times 0{\cdot}047}{10} = 0{\cdot}47$ gram.

$\therefore$ there is 0·47 gram of cane sugar in 5 c.c. of stock solution, or in 1 gram of condensed milk.

$\therefore$ the total sugar content expressed as cane sugar is 47%.

But in this 47% there is a certain amount of lactose.

From the lactose estimation let it be supposed that 15% was present. The reducing power of lactose as compared with that of cane sugar is as 0·0678 is to 0·047.

$\therefore$ percentage of lactose $\times \frac{0{\cdot}047}{0{\cdot}0678}$ = percentage of cane sugar.

$$\therefore \qquad \frac{15 \times 0{\cdot}047}{0{\cdot}0678} = 10{\cdot}4.$$

This means that the lactose expressed as cane sugar is 10·4%.

We now know that of the 47% of total sugars, 10·4% is due to lactose.

$\therefore$ 47 − 10·4 = 36·6% of cane sugar present.

BUTTER

The composition of butter may be taken as being—

Fat	83·5%	
Casein	1·0%	
Sugar	1·0%	
Ash	1·5%	
Water	13·0%	(Legal Limit . 16%)

The legal limit of water in milk-blended butter is 24%, and in margarine 16%.

The process which chiefly concerns the Public Health student is that which differentiates butter from margarine.

Whatever process to this end is employed, the pure fat from the sample must be obtained.

1. Place some of the sample in a small beaker, which is immersed in a larger beaker containing water maintained at a temperature of 50° C. by a small bunsen flame.
2. Allow to stand for twenty to thirty minutes, or until the fat has separated out and floats on the top.
3. Gently decant supernatant fat on to a dry filter-paper kept hot by a special hot-water funnel.

N.B.—The filter must be dry; if wet, the rate of filtration will be considerably diminished.

The filtrate will be pure fat.

A much quicker method is as follows—

1. Place some of the sample in a test-tube.
2. Melt fat by immersing tube in hot water.
3. Centrifugalise for two minutes.
4. By means of a glass rod, gently push a wad of cotton-wool

through the upper layer of fat to the layer of casein below. The fat oozes through the wool and is filtered in that way.

Reichert-Wollny Process for estimating the amount of soluble volatile fatty acids in terms of $\frac{N}{10}$ alkali.

1. Into a small (300 c.c.) wide-mouth flask weigh 5 grams of the fat (5·8 c.c. will do for most practical purposes).
2. Add 10 c.c. of 92% alcohol and 2 c.c. of well-shaken 50% caustic soda solution.
3. Attach a reflux condenser, *i. e.* to the flask fit a cork which takes a long (2 feet) glass tube.
4. Place on hot-water bath for fifteen minutes.
5. Remove reflux condenser, keeping flask on bath until all the alcohol is driven off and a soap remains. This step may be accelerated by placing the flask on its side and occasionally rotating it.
6. Add 100 c.c. of boiling distilled water, and shake until soap is dissolved.
7. Cool down to about 50° C.
8. Add 40 c.c. of sulphuric acid solution (1 in 40), followed by two small pieces of pumice stone to prevent bumping on boiling the mixture.
9. Attach flask to a special condenser fitted with an anti-splasher, and distil over 110 c.c., allowing the distillate to drop on to a filter-paper to remove any insoluble fatty acid which may be volatilised.
10. Estimate the acidity of this filtered distillate in terms of $\frac{N}{10}$ alkali, using phenolphthalein as an indicator. As a rule, pure butter requires at least 24 c.c. of $\frac{N}{10}$ alkali, and margarine takes very seldom more than 2 c.c. A sample requiring an amount between 2 and 24 c.c. is presumed to be a mixture. For example, if the figure was 15 c.c., what is the percentage amount of adulteration ?

$$24 - 2 = 100\% \text{ butter}$$
$$15 - 2 = \ ?$$
$$= \frac{100 \times 13}{21} = 61{\cdot}9\% \text{ of pure butter, or } 38{\cdot}1\% \text{ of adulteration.}$$

Valenta Test.

1. Add 3 c.c. of the fat to 3 c.c. of glacial acetic acid in a test-tube.
2. Shake well; mixture will become turbid.
3. Heat gradually, and note temperature at which mixture clears. Butter clears as a rule below 50° C., whereas margarine does not usually clear below 80° C.

Preservatives are the same as for milk, and are detected in the same way, but the tests are applied to the water of the sample.

To get the water, the following method is quick and convenient—

1. Place some of the sample in a test-tube.
2. Cork the tube.
3. Melt sample by immersing tube in hot water.
4. Centrifugalise tube upside down. The water will now be resting on the cork.
5. Solidify the fat; this will allow one to remove the water.

N.B.—A little extra water may be added to the liquid butter before centrifugalisation.

FLOUR

The composition of ordinary flour is approximately—

Protein	12·5%
Carbo-hydrates	71·1%
Fat	1·2%
Sugar	1·3%
Fibre	0·04%
Ash	0·7%
Water	12·8%

Physical Characters.—It should be white in colour, have no musty or acid smell, and be almost tasteless. When gripped between the thumb and finger, it should feel smooth, and knit well together. On mixing with a little water, the dough should be sticky, and should draw out into a stringy mass without easily breaking. It should be free from animal and vegetable parasites.

Moisture.—This may be estimated by drying a weighed amount of the material in a platinum dish on the water-bath, until a constant weight is obtained. It should not exceed 15%.

Mineral Matter.—The moisture-free flour from the above experiment is incinerated to a white ash, using a small flame to commence with, which may be increased as the incineration proceeds. The residue is weighed and calculated to a percentage. It should not exceed 1%.

"*Improvers,*" which consist mainly of acid potassium and magnesium phosphates and potassium persulphate, will increase the amount of ash, in which their presence can be detected.

Nitrogen peroxide has been used to bleach flour. It can be detected by washing the flour in water, and testing the water for nitrite with meta-phenylene-diamine. Flour may normally contain nitrites. If, however, the amount exceeds 1 part per 1,000,000, in all probability it has been bleached.

Gluten Estimation.—Weigh into a porcelain bowl 50 grams of the flour. Add water very slowly, mixing all the time, until a

solid dough is produced. Transfer dough to a piece of linen cloth, previously weighed; make into a small bag by twisting up the ends.

Knead the dough thoroughly under running water, until the water from the bag contains no starch, that is, until the washings become clear and no blue colour results when iodine is added. Allow to drain well, and then dry in hot-air oven. Reweigh bag, and calculate to a percentage. The average forms 8 to 12%.

Kjeldahl's Process for Estimating the Total Amount of Protein.—Weigh 0·5 gram of the flour into a small hard glass flask. Add 20 c.c. of nitrate-free strong sulphuric acid. Place flask in fume cupboard. Apply heat gently, until the acid becomes black, when the heat may be increased.

If the charred condition persists, add a few crystals of potassium sulphate. This, by raising the boiling-point of the acid, accelerates the process. A small amount of potassium permanganate (solid) may also be added, to increase oxidation.

Continue heating until the charring has disappeared and the acid presents a pale yellow colour, or is even colourless.

Now transfer to a larger distilling flask, wash out the small flask several times with ammonia-free distilled water, pouring the washings into the larger flask. Repeat this until in all there are about 250 c.c.

Render alkaline with an ammonia-free solution of caustic soda to liberate the ammonia in combination with the acid.

Attach flask to a condenser, and distil over about 250 c.c., allowing the distillate to drop into a flask containing 50 c.c. of $\frac{N}{10}$ sulphuric acid.

Now estimate the acidity of the whole, in terms of $\frac{N}{10}$ soda solution, using methyl orange as an indicator.

Calculation.—Say 40 c.c. of $\frac{N}{10}$ soda were required.

Then obviously 10 c.c. of $\frac{N}{10}$ acid have been neutralised by the ammonia which has distilled over.

Hence the ammonia derived from 0·5 gram of flour is equal to 10 c.c. of $\frac{N}{10}$ solution.

1 c.c. of $\frac{N}{10}$ solution = 0·0014 gram of N.

$\therefore$ 10 c.c. = 0·014 gram of N.

$\therefore$ there is 0·014 gram of N in 0·5 gram of flour, or 2·8 grams in 100 grams of flour.

As nitrogen forms about 16% of protein, the proportion of nitrogen to protein is as 16 is to 100, or as 1 is to 6·3.

$\therefore 2{\cdot}8 \times 6{\cdot}3 = 17{\cdot}64\%$ of protein.

To examine flour microscopically for the detection of other starches which are sometimes added, place a very small amount on a clean glass slide, add a drop of water, cover with a slip, squeeze gently to produce an even layer of the flour, and examine at once with the $\frac{1}{4}$-inch objective.

The starches present the following microscopical characters (Kenwood)—

1. Large round or oval granules with no marked concentric striæ.

Wheat.—A mixture of large and small granules.

Barley.—Granules intermediate in size occur. Shape more irregular.

Rye.—May show a stellate hilum.

2. Large pyriform granules, well-marked concentric striæ and hilum.

Potato.—Hilum at point.

Arrowroot.—Hilum at broad end.

3. Oval granules uniform in size, faint striæ, central linear hilum.

Pea and **Bean.**—The hilum of the bean granule is more commonly puckered.

4. Small angular granules, no striæ.

Rice.—Usually in angular masses.

Oatmeal.—Usually in rounded masses.

Maize.—Clearly defined granules, not in masses, stellate hilum.

5. Irregular in shape, usually oval, with the pointed end cut away, central hilum.

Sago and **Tapioca,** the former being larger.

Much practice is needed to enable the student to distinguish the various granules.

BREAD

Composition (moisture-free)—

Starch, dextrin, etc.	82·2%
Protein matter	11·2%
Maltose	4·1%
Fat	0·7%
Salts	1·8%

Moisture.—This is estimated as in flour. Care should be taken to obtain an average sample of the bread. The crust contains less moisture than the crumb, and therefore the sample examined should contain a due proportion of each. It should not exceed 40%.

Ash.—This is estimated as in flour. It should not exceed 2–3%.

Acidity.—Weigh 10 grams of the crust and crumb into a glass beaker. Add 100 c.c. of distilled water. Allow to stand for one hour, kneading the bread with a glass rod occasionally. Filter off 50 c.c. and estimate the acidity in the ordinary way, using phenolphthalein as an indicator, and calculating the answer as a percentage of acetic acid (1 c.c. $\frac{N}{10}$ alkali = 0·006 gram of acetic acid). It should not exceed 0·12%.

Test for Alum.—The following reagents should be freshly prepared—

An alcoholic tincture of logwood, made by digesting about 5 grams of logwood chips in 100 c.c. of alcohol.

A saturated solution of ammonium carbonate.

Mix 5 c.c. of each and make up to the 100 c.c. with water. Pour this over a fairly large piece of the bread, drain off the excess, and dry in the hot-air oven. A blue or lavender colour indicates the presence of alum; a brown colour develops in its absence.

INFANTS' FOODS

The **moisture** is estimated in the ordinary way. It should not exceed 5%.

The **proteins** are estimated by Kjeldahl's Process.

The **fat** content, of say 1 gram of water-free food, may be determined by Schmidt's Process, or by Adam's Process.

In the latter method the sample is placed in a fat-free paper thimble, which is then transferred to a Soxhlet fat-extraction apparatus. The ether in a weighed flask is evaporated by gentle heat, condensed in a condenser at the top of the apparatus, and collected in the chamber in which the thimble has been placed. It returns by siphonage to the weighed flask, carrying the fat back with it. The process is automatic, and should be allowed to continue for a period of three to four hours. At the end of this time the flask is detached, the ether evaporated, the flask reweighed, and the fat calculated to a percentage.

The **sugars** are determined as in condensed milk. Weigh some of the material, and mix thoroughly in the cold with a known amount of water. This will dissolve any sugar present leaving the starch unaffected. Filter; the filtrate will be free from starch. The sugar, direct and after inversion, can now be estimated in the filtrate.

The **starch** is estimated by a process of elimination. Everything else is calculated to a percentage, and the total deducted from 100. The difference represents starch. The ordinary hydrolysing process for starch is unsatisfactory, as some of the glucose resulting from the process of inversion is destroyed.

If the food is merely a milk powder, by adding about seven times as much water as powder, bringing to the boil, and well stirring, a mixture very closely resembling cows' milk is obtained. This can now be analysed as if it were ordinary milk.

ALCOHOLIC BEVERAGES

Beer.—To estimate the amount of alcohol, measure 300 c.c. into a boiling flask. Attach flask to a condenser, and distil over 200 c.c. Make up with water to 300 c.c. and determine specific gravity as follows—

Weight of dry specific gravity bottle = A.

Weight of bottle full of distilled water = B.

Weight of bottle full of distillate at the same temperature as the distilled water = C.

$$\text{Specific gravity} = \frac{C - A}{B - A}.$$

Consult "Alcohol Tables" to see the percentage amount of alcohol that corresponds to the specific gravity obtained.

Percentages range from two in light ales to about eight in the heavy stouts.

Acidity.—Dilute 20 c.c. of the sample with distilled water to 100 c.c. (Black beers may be sufficiently decolorised with neutral lead acetate solution to allow the change of colour to be observed.) Add $\frac{N}{10}$ soda solution, using phenolphthalein as indicator, and note the amount required to affect neutrality. The acidity of 100 c.c. should not exceed 30 c.c. of the decinormal solution.

The **ash** is estimated in the ordinary way. The amount should fall between 0·1 and 0·3%. Mineral matter has probably been added if the latter figure is exceeded. The common salt figure is calculated by digesting the ash in distilled water, and estimating the chlorine with S.S. silver nitrate and potassium chromate. Although this method usually under-estimates the amount, it is near enough for most practical purposes. As the amount of chlorides in the water from which the beer was made must obviously affect the final result, the Board of Inland Revenue state that no inquiry is necessary unless the amount found exceeds 50 grains to the gallon of beer.

For Arsenic in beer, see p. 381.

Spirits.—According to the Sale of Food and Drugs Amendment Act, whisky, brandy, and rum may be 25% "under proof," and gin 35% "under proof."

(Relaxed under war conditions to 50% under proof.)

"Proof spirit" contains 57·06% of alcohol by volume, or 49·24% by weight. Its specific gravity is 0·9198 at 15° C. The specific gravity of absolute alcohol is 0·7938.

Percentage of alcohol by volume multiplied by 1·75 equals degrees or percentage of "proof spirit."

Required to find the percentage amount of added water in a whisky containing only 60% of proof spirit—

As whisky may not be more than 25% under proof it must contain 75% of proof spirit. This sample, therefore, contains $\frac{60}{75}$ of what it should contain.

This fraction expressed as a percentage is $\frac{60 \times 100}{75} = 80.$

∴ 80% of whisky is present, or 20% of water has been added in excess of that allowed by law.

The alcohol is estimated by diluting 100 c.c. of the spirit to 300 c.c. with water, and distilling over *exactly* 200 c.c. The specific gravity of the distillate is determined in precisely the same manner as already indicated. The alcohol figure of this specific gravity is multiplied by two to bring it to a percentage, since the volume of distillate is double the volume of spirit taken for the estimation.

The acidity of brandy is about 0·05 to 0·1%, of whisky about 0·1%, and of rum about 0·5%.

Wines.—The alcohol content is estimated as in spirits. The amount varies from 8–20%.

The **total acidity** is estimated in a white wine after much dilution, and calculated as tartaric acid. It should not exceed 1·2%. 1 c.c. of $\frac{N}{10}$ soda solution = 0·0075 gram of tartaric acid.

In the case of a red wine, the colour masks all end reactions. As a rule, however, the colouring matter of the wine is in itself an indicator, becoming green when the neutral point is reached.

The **volatile acids** form about one-fourth to one-third of the total acids. The volatile acids can be estimated in the distillate of the wine, expressing the result in terms of acetic acid.

Foreign colouring matter can be detected by immersing in the wine for twenty-four hours cubes of 10% gelatine, three-quarters of an inch square. In pure wines the colouring matter penetrates the gelatine only for about one-sixteenth of an inch, but foreign colouring matter penetrates almost to the centre of the cube.

Calcium sulphate, added to improve the colour and keeping qualities, may be estimated by precipitating it with barium chloride solution and hydrochloric acid, and calculating the result as potassium sulphate. In France a limit of 0·2% is allowed. The addition of this salt is known as "plastering."

The **ash** of genuine wine is about 0·1 – 0·3%.

The **chemical preservatives** added to wine are *boric acid, formalin*, and, more commonly, *salicylic acid*. Boric acid is tested for as in milk. For formalin the wine is distilled, and the

sulphuric acid test applied to the distillate. Salicylic acid may be detected by acidulating with sulphuric acid, adding an equal volume of ether, thoroughly shaking, allowing ether to separate out, decanting it off, evaporating to dryness, and testing the residue with ferric chloride solution. A purple colour indicates the presence of salicylic acid.

Sulphites are sometimes found in beer. To test for them, add to some of the beer in a glass cylinder a few pieces of granulated zinc and hydrochloric acid. The hydrogen generated reduces the sulphites, and sulphuretted hydrogen is evolved, which darkens a moistened lead acetate paper placed over the mouth of the cylinder. As the reagents employed sometimes give positive results, it is advisable to test them prior to use.

ARSENIC IN BEER, ETC.

1. *Reinsch's Test.*—To 200 c.c. of beer in a porcelain bowl add 30 c.c. of pure strong hydrochloric acid, and a piece of bright copper foil. Boil for forty-five minutes, adding water occasionally to replace that lost by evaporation. If it is tarnished, or a deposit has formed, wash the foil in water, and then in alcohol and ether. When dry, it should be placed in a reduction tube, and heat applied. If a sublimate is obtained, examine it microscopically for the presence of the characteristic octahedral and tetrahedral crystals of arsenious oxide. Sulphites and organic matter both tarnish the foil, but neither furnish a sublimate.

2. *Marsh's Test.*—The apparatus and all chemicals used must be tested to ascertain if they are arsenic free. The granulated zinc should be washed thoroughly in water to remove all dust. Having charged the drying tube of the apparatus with lead acetate paper to absorb the sulphides, and with calcium chloride to absorb any moisture as it passes through, a blank experiment is performed. If the hydrogen burns with a blue flame, with no suggestion of a lavender colour, and no dark deposit is formed when a cold porcelain slab is held obliquely in the flame, everything may be considered free from arsenic.

Ten to twenty c.c. of the beer to be tested are now slowly added through the funnel of the apparatus. Note any change of colour of the flame. A lighted bunsen burner is also placed under the glass tube about 3 inches from the hydrogen flame. In the presence of even a very small amount of arsenic a deposit or mirror of a brown colour will be apparent in the glass tube. If a known quantity of beer has been added, the amount of arsenic present can be determined by comparing the mirror obtained, in say twenty minutes, against a set of standard mirrors, each one of which has been produced by a known amount of arsenic in the same period of time.

The test may be applied to portions of wall-papers cut into small fragments. If any special colour is suspected, this may be examined separately.

Foods may be digested for some hours in hydrochloric acid, and the acid tested. Or the food, after very careful ignition to destroy organic matter, may be added direct to the apparatus.

The Royal Commission on Arsenical Poisoning stated that, when foods contain $\frac{1}{100}$ grain of arsenic or more per gallon or pound, action should be taken under the Sale of Food and Drugs Act.

VINEGAR

The **specific gravity** of a strong vinegar, that is, one containing about 5% of acetic acid, is about 1020, water being taken as 1000.

The **acidity** is estimated by titrating 10 c.c. of a 10% solution of vinegar in water with decinormal soda solution, using phenolphthalein as an indicator. Let 9 c.c. of decinormal solution be required to affect the change of colour. As 1 c.c. of decinormal solution = 0·006 gram of acetic acid, ∴ 9 c.c. = 0·054 gram.

∴ there is 0·054 gram of acetic acid in 1 c.c., or 1·02 gram, of vinegar.

$$\therefore \qquad \frac{0{\cdot}054 \times 100}{1{\cdot}02} = 5{\cdot}3\% \text{ of acetic acid.}$$

To test for the presence of mineral acids, the ash is obtained, which is alkaline in the absence of a mineral acid. If to an alcoholic solution of methyl orange some vinegar is added, a red colour indicates the presence of a mineral acid. Organic acids do not react to the above indicator.

COFFEE

The **moisture** of roasted coffee, which should not exceed 0·6%, is estimated by drying a known amount at 100° C. until a constant weight is obtained, and then calculating.

The presence of **caffein** may be detected by placing some of the material in a watch-glass, which is then covered by another in an inverted position. Gentle heat is applied. Long needle-like crystals (of caffein) appear on the under surface of the upper watch-glass.

To test for the presence of **chicory,** place some of the sample on the surface of some water in a conical test-glass. As coffee contains fat, it floats, whereas chicory sinks. Collect the deposit, and boil it for a few minutes in water, then examine microscopically. Coffee cells are long, complete, and tapering, with a dotted appearance in their centres. Chicory shows a structure with square-cut ends, giving it an appearance of an incomplete cell, with a characteristic spiral formation in its centre.

The amount of chicory present can be estimated approximately by determining the specific gravity of a 10% infusion. Twenty grams of the sample are added to 200 c.c. of water. The mixture is raised to the boiling-point, filtered, cooled to about 15° C., and the specific gravity of the filtrate calculated. Pure coffee decoctions give a specific gravity of about 1009·5, while chicory gives one of about 1025·5, a difference of 16. Supposing the specific gravity of a sample to be 1014·3, the difference of 11·2 (1025·5 — 1014·3), expressed as a percentage of 16, is the amount of coffee present in the mixture.

Or, if a difference of 16 $= 100\%$ coffee,

$$\text{a difference of } 11{\cdot}2 = \frac{11{\cdot}2 \times 100}{16} = 70\% \text{ coffee.}$$

$\therefore$ 30% of chicory has been added.

LIME JUICE AND LEMON JUICE

The Board of Trade standard for these juices is a **specific gravity** of 1030 (without alcohol) and an acidity equal to 30 grains of citric acid per ounce.

They are sometimes fortified with brandy, which acts as a preservative. The alcohol may be estimated in the ordinary way, and amounts at times to quite 4%.

The **acidity** is calculated in terms of citric acid. One c.c. of a decinormal solution of soda = 0·0069 gram of citric acid. The percentage amount of acid × 4·375 = grains per ounce.

Tartaric acid is tested for by first neutralising with caustic soda, and then adding calcium chloride solution. On vigorous shaking a precipitate of calcium tartrate falls.

Salicylic acid and *sulphites* are sometimes added as preservatives. Their presence can be detected by the ordinary tests.

PEPPER

The chief adulterants are starches (mainly rice), "poivrette," which consists of ground olive stones, and mineral matter.

The presence of starches may be detected by microscopical examination, and may be confirmed by the iodine test. "Poivrette," as it does not contain starch, will give a negative result to the iodine test.

If some of the pepper be shaken with chloroform, the mineral matter sinks. Due allowance must be made for the presence of mineral matter which unavoidably gains access during the process of collecting the berries from the ground, and in the course of grinding.

The ash figure is very useful. The limit for black pepper is 6·5%, 2% being insoluble in hydrochloric acid, and for white pepper 3·5%, 1% of which is insoluble in hydrochloric acid.

If pure hydrochloric acid is poured over some of the sample in a test-tube, unadulterated pepper becomes an intense and uniform yellow. If this is now spread out into a thin layer, the foreign ingredients can be detected as they remain uncoloured.

MUSTARD

The two commonest forms of adulteration are the addition of starch and the addition of colouring matter.

Starch is detected by boiling a small amount in water, cooling, and adding a weak iodine solution, when a blue colour results.

The colouring matter is usually turmeric, which turns an orange red on adding ammonia. It may also be detected by making a solution of the mustard in alcohol, filtering, and saturating a filter-paper with the filtrate. The paper is then dried, and dipped in a solution of boric acid containing a drop or two of hydrochloric acid. If the paper is again dried, it assumes a pink colour in the presence of turmeric, and turns to a bluish green on adding weak ammonia.

DISINFECTANTS

1. **Estimation of the free chlorine in bleaching-powder.**—Weigh 1 gram of the powder, and mix thoroughly in 100 c.c. of water. Remove 10 c.c. into a white porcelain bowl. Add from a burette a decinormal solution of sodium arsenite until no blue colour is produced when a drop from the bowl is brought in contact with a piece of starch and iodide paper. Note the amount of solution required. Let this equal A (say 10·3 c.c.). Then add to the bowl a few drops of starch solution. Again from a burette add a decinormal solution of iodine until a blue colour is permanent. Note the amount added, and let this equal B (say 0·3 c.c.).

Since B represents the excess of arsenite solution added, $A - B =$ the free chlorine in 0·1 gram of bleaching-powder (10 c.c. were taken from 100 c.c. containing 1 gram) expressed as decinormal solution, that is, $10·3 - 0·3 = 10$ c.c.

1 c.c. of decinormal solution = 0·00354 gram of chlorine.

$\therefore$ 10 c.c. = 0·0354 gram.

$\therefore$ there is 0·0354 gram of free chlorine in 0·1 gram of bleaching-powder, or 35·4%.

The amount should be about 33%.

A very good alternative estimation is as follows—

To 10 c.c. of the mixture in a porcelain bowl add a few drops of sulphuric acid and an excess of potassium iodide solution. The yellow colour which results is discharged by adding $\frac{N}{10}$ solution of sodium thiosulphate.

Say 8 c.c. of the $\frac{N}{10}$ solution were required.

1 c.c. of $\frac{N}{10}$ solution = 0·00354 gram of Cl.

∴ 8 „ „ = 0·02832 „ „

∴ there is 0·02832 gram of Cl in 0·1 gram of bleaching-powder, or 28·32%.

When bleaching-powder is exposed to moist air, the carbonic acid decomposes it into calcium carbonate and free chlorine.

$CaOCl_2$ (bleaching-powder) $+ H_2CO_3 = CaCO_3 + H_2O + Cl_2$.

A different reaction, however, occurs when the bleaching-powder is in solution. Calcium chloride and calcium hypochlorite are formed, in accordance with the following equation—

$$2CaOCl_2 = CaCl_2 + Ca(ClO)_2.$$

The calcium hypochlorite is an oxidising agent, as $Ca(ClO)_2 = CaCl_2 + O_2$.

2. **Estimation of the strength of a solution of potassium permanganate.**—Add to a porcelain bowl 20 c.c. of a decinormal solution of oxalic acid. Render markedly acid with 5 c.c. strong sulphuric acid. Then run in the solution of potassium permanganate until the pink colour no longer disappears. Note the amount required.

Calculation.—Say 8 c.c. were added.

Then 8 c.c. of potassium permanganate solution equal 20 c.c. of a decinormal solution. For, if the potassium permanganate solution had been decinormal, 20 c.c. would have been required.

1 c.c. of decinormal solution = 0·00316 gram of potassium permanganate.

∴ 20 c.c. = 0·0632 gram.

∴ 8 c.c. of the solution contain 0·0632 gram.

∴ 100 c.c. contain $\frac{100 \times 0{\cdot}0632}{8} = 0{\cdot}79$ gram.

∴ the strength of this solution of potassium permanganate is 0·79%.

$5H_2C_2O_4 + K_2Mn_2O_8 + 3H_2SO_4 = K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$.

3. **Estimation of the amount of tar oils in crude carbolic acid.**—To 10 c.c. of the sample in a graduated cylinder add 40 c.c. of a 10% solution of caustic soda. Shake well, and allow to stand for thirty minutes. The amount of oily stratum above or below, according to whether the oils are light or heavy, can be read off on the graduations of the tube. Calculate to a percentage, *e. g.* 3 c.c. of oil separated = 30%.

4. Various disinfectants can be identified as follows—

Copper Sulphate.—Hydrochloric acid and potassium ferrocyanide solution = bronze colour.

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Zinc Chloride.—The above test gives a gelatinous white precipitate.

Perchloride of Mercury.—Potassium iodide gives a red precipitate soluble in excess of potassium iodide.

Sulphurous Acid.—Silver nitrate = white precipitate soluble in strong nitric acid.

Carbolic Acid.—If a solution, clear and colourless, add ferric chloride solution = purple colour, or bromine water = white precipitate.

If a solution, but turbid, dilute with an equal quantity of water, add a drop or two of sulphuric acid, and distil over a few cubic centimetres. Test distillate with ferric chloride and bromine water as above.

If a powder, place some of the powder in water, add sulphuric acid, and perform the distillation test.

Formalin.—If a solution and colourless, add a drop or two of 5% phenol to the disinfectant in a test-tube, and pour down the side of the tube strong sulphuric acid; a crimson zone is positive.

If a turbid solution or powder, add water to the powder, distil over a small amount, and test that as above.

5. To judge the germicidal efficiency of a disinfectant, the **Rideal-Walker Method** is usually employed, a "*carbolic acid coefficient*" being obtained.

If a disinfectant has a coefficient of, say 10, this implies that where carbolic acid made up to a certain strength will kill the typhoid fever organism (this being the one employed for the test) in a certain time, the disinfectant made ten times more dilute than the carbolic acid will kill the same organism in the same time.

The *modus operandi* of the test is as follows. Five drops of a twenty-four hours' old broth culture of the bacillus typhosus are placed in a small sterile flask, followed by 5 c.c. of a known dilution of the disinfectant. Exactly at the end of five minutes a platinum loopful of the mixture is sown in a tube of broth (the loop must measure 3 mm. in diameter). This is repeated at the end of ten and fifteen minutes. Various dilutions of the disinfectant and of phenol are treated in precisely the same manner. Then all the inoculated broth tubes are incubated at 37° C. for forty-eight hours. The tubes are now inspected and a table compiled, a growth being indicated as a plus, and no growth as a minus.

The following is a typical table—

		5	10	15
Phenol	1–100 . . .	+	—	—
Disinfectant	1–1400 . . .	+	+	+
„	1–1200 . . .	+	+	—
„	1–1000 . . .	+	—	—
„	1–800 . . .	—	—	—

These results indicate that the B. Typhosus is killed when exposed to the action of 1% phenol for ten minutes, and that the unknown disinfectant also kills in the same time when made up to a dilution of 1–1000.

$$\therefore \text{ the carbolic acid coefficient} = \frac{1000}{100}, \text{ or } 10.$$

This test is purely a laboratory one, with all the usual errors when viewed in the light of practical application and of natural conditions. It is obvious that the unprotected organism is under the direct influence of the germicidal agent. In order to bring the disinfectant to a condition under which it is likely to be employed, sterilised organic matter, as dried fæces, has been added to the sterile water with which the dilutions are made. It has been proved experimentally that the addition of organic matter has an unequal effect, whereby the power of the phenol is reduced to a less degree than is the power of many of the disinfectants which are in common use. This means a lowering of the coefficient. At the same time it must be remembered that all disinfectants are treated alike, and therefore should be strictly comparable. It is probably the best test we have for standardising purposes.

The germicidal power of a coal tar disinfectant must necessarily depend upon the amount of phenoloid bodies present. Chemical analysis, however, is apt to overstate the power, for if two disinfectants, one being an emulsion and the other a solution, contain the same percentage amount of phenols, the emulsion will have a higher coefficient, as disinfection is better realised with emulsions than with solutions. This increase of efficiency is due to Brownian movement of the active emulsified agent. The organism adsorbs the germicide, and in that way is subjected to a greater concentration of the agent. This probably accounts for the lowering of the coefficient when organic matter is added. The organic particles also adsorb the agent, thus reducing the amount left over for disinfecting purposes.

It appears from the experiments conducted by the "Lancet Commissioners" that, when Coli Communis is the test organism, the germicidal power of the phenoloid bodies is in *inverse ratio* with their *bromine values*. Each phenoloid body has its own specific bromine value. If the amount of phenoloids be estimated, firstly by extracting and weighing them, and then by the bromine method (calculating them in terms of phenol), it is obvious that, if phenol is the only phenoloid present, the two estimations will agree. But if phenol is absent, then the estimations will not coincide, and the greater the difference between them the lower the bromine value must have been, and therefore the more germicidal are the phenoloids which are present. From this it must follow that if P represents the percentage amount of phenoloids by weight, and B the percentage amount as deter-

mined by the bromine method, P — B will indicate the germicidal efficiency, when comparisons are instituted against various disinfecting fluids. If P — B is divided by 3, it is found that a figure results which is in close approximation to the coefficient found by bacteriological means. The formula fails in two ways: (1) if phenol only is present, then, as we have seen, P = B, which implies that phenol has no disinfecting value at all; and (2) it does not differentiate between emulsions and solutions. The formula for solutions is $\frac{P - B}{6}$. This again accentuates the advantage of emulsions, as it indicates that an emulsion is twice as efficient.

A SHORT LIST OF TEXT-BOOKS

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